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The Research Quarterly

of the

American Physical Education Association

Vol. I DECEMBER, 1930 No. 4

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The Circulatory Reaction in Standing*

By Abby H. Turner

Department of Physiology, Mount Holyoke College, South Hadley, Mass.

THE most important business of the circulatory apparatus is to so adjust itself that enough blood for the needs of the body at any particular time will be delivered to the parts needing it. This is no small matter, for at one moment there must be economy of body heat and therefore less blood to the skin, two minutes later muscular activity may be raised ten-fold and surplus heat may be the problem as well as the requirements of the active muscles. Again, the digestive system and its glands may call loudly. Or the mechanism may be confronted with the task of transporting blood in tubes all at one level, approximately, while at the next instant we spring to our feet and the whole apparatus is set on end.

Of this multiplicity of adjustments one has been especially well-studied, the response of the circulatory mechanism to exercise. In this we see the cooperation of many parts, conspicuously an increased return of blood to the heart because of the suction of augmented respiration and the massage of the exercise itself, with accompanying increase in force and rate of the heart. A dilatation of arterioles in the active regions combines helpfully with enough constriction elsewhere so that systolic pressure is high, diastolic not low, with a consequent wide pulse pressure suggesting a large output from the heart per beat. There is in the active regions the opening of large numbers of capillaries previously closed as well as the dilatation of all, so that the needy tissues may be flooded with blood. A recent discovery is the participation of the spleen which presses out stored blood rich in corpuscles so that the total circulating volume is augmented and the power of oxygen carriage especially increased.

The accurate grading of all these responses to the amount of exercise has been carefully checked by comparative studies of the use of oxygen. The parallel changes are most impressive in their accuracy of adjustment. (See Bainbridge for many data.)

At the Mount Holyoke Physiological Laboratory we have been for the last few years especially concerned with the picture of the adjustments, not in exercise, but when a young woman after a period of reclining rises and stands quietly for some time, in other words

* Substance of a paper given before the Research Section of the Boston meeting of the American Physical Education Association, April 3, 1930.

with the response of the circulatory apparatus to changes in gravity relationships. Emphasis is placed on two things, *quiet* standing (the avoidance of unnecessary exercise) and standing for *some time* (endurance). This vertical position is a difficult one when we think of the circulation of the blood in its varied vessels, and bear in mind the position of the controlling centres, high up in the medulla, where in case of any lack of distribution blood will go with difficulty. Do we meet this relatively new problem, as phylogenetic biological problems go, with entire success?

Evidence must be gathered from many sources. In the first place, how great is the need for extra blood to meet the additional exercise of standing as compared with reclining? This has been found by several sets of experiments (Benedict and Benedict, 1924; Turner, 1927a; Turner, Newton and Haynes, 1930) to be very small, for there is in standing an increase over the reclining oxygen consumption of only 10 to 20 per cent. In comparison, the exercise of walking about two miles an hour raises the oxygen consumption by 200 per cent (Benedict and Murschhauser, 1915) while the rise in heart rate is about the same as in standing. Obviously the very slight rise in oxygen consumption during standing fails conspicuously to explain the circulatory adjustment.

There are several ways of determining, though indirectly, the output of the heart. In exercise it is agreed, with concordant results from different methods, that the increase in heart rate and in the minute output of the heart are both approximately proportional to the rise in oxygen consumption. In standing we have a similar increase in heart rate, but while all observers agree that the output of the heart per minute does not rise appreciably, there is disagreement as to whether it remains about the same, (Grollman, 1928, 1930) or decreases in most persons (Field and Bock, 1925; Turner, 1927a). But there is surely a decreased output per beat, in harmony with the narrow pulse pressure which is found. This is due to a rise in diastolic pressure, for the systolic pressure remains about the same or rises or falls but slightly. The diastolic pressure, then, gives evidence of a vasoconstriction somewhere, and it apparently helps to maintain the blood flow to the head. To some of us at least, the narrow pulse pressure indicates a restricted return of blood to the heart in a way only slightly less convincing than the measurement of the circulatory minute volume. Obviously the adjustment is a difficult one, with so much of the blood sent below the heart, to return up hill under a venous pressure at best scarcely adequate for the task imposed upon it.

Our study of the details of this gravity reaction had to do, for one point, with its first precision. In exercise the circulatory adjustment is well graded to the need; is circulatory adjustment also neatly matched to the way the body is situated in space? To answer this,

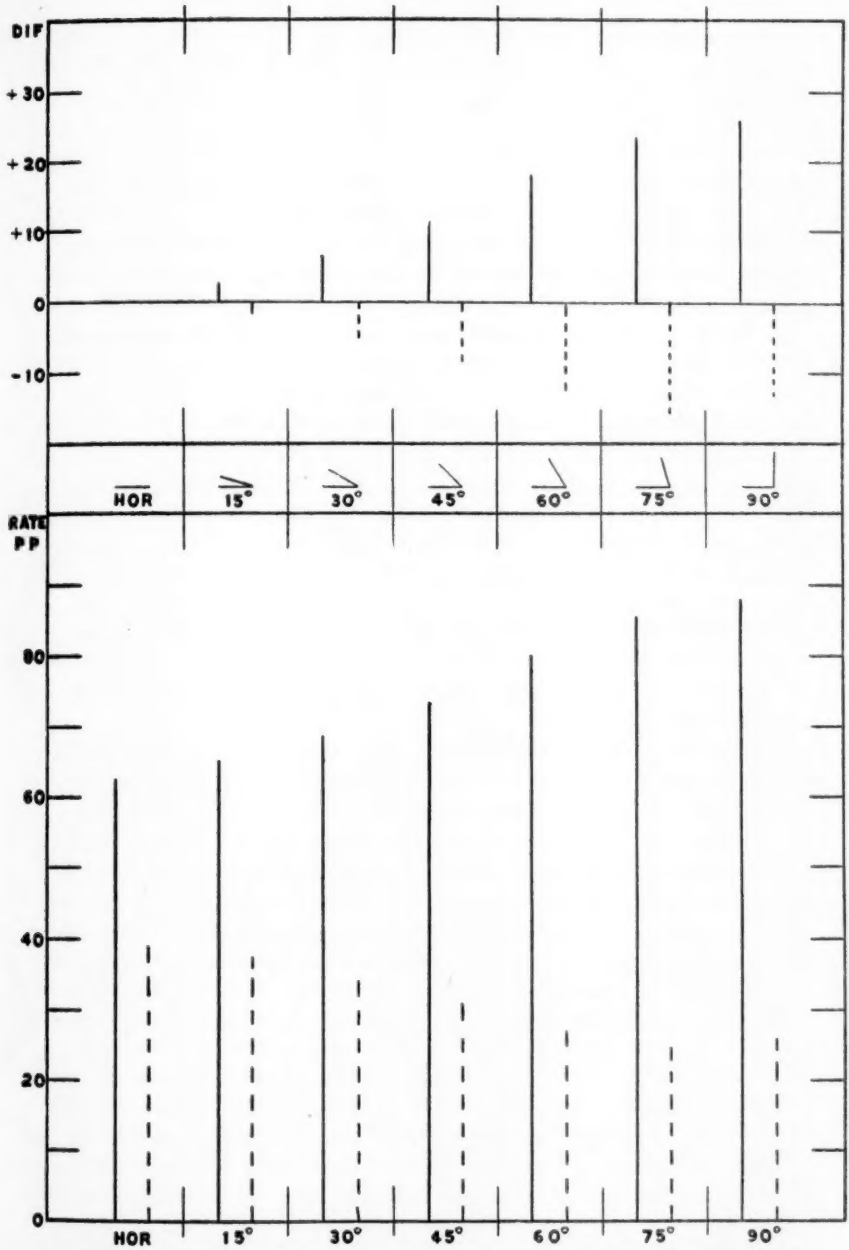

Figure 1. Relation of circulatory adjustment to tilting to different angles indicated. Averages of 15 experiments on 11 subjects. Six minutes in each position, with return to horizontal after each angle. Averages of minutes 3 to 6, inclusive, are used, since minutes 1 and 2 showed adjustment to new position.

Lower chart, actual findings. Continuous lines, heart rates in beats per minute as shown in left margin. Dotted lines, pulse pressures in mm Hg also in left margin.

Upper chart, differences for each angle and horizontal. Increase in heart rate shown above O-line, in beats per minute. Decrease in pulse pressure shown below O-line in mm Hg. See text for comment on 90 degree pulse pressure.

young women were placed on a tilting board and tilted for a brief period, six minutes, to each of these angles, 15, 30, 45, 60, 75 and 90 degrees. After each tilting there was return for six minutes to the horizontal. The nature of the response is shown in Figure 1, and surely nothing more precise could be asked than this gradual progression in rise of heart rate and narrowing of pulse pressure, as the angle gets steeper and steeper. There seems to be a flaw in the curve for the 90 degree angle, due probably to the inadvertent movements which every subject made when she found herself actually vertical and on her own feet. She shifted a bit to better her balance and slight as the movements were they undoubtedly helped some blood to the heart, thus lessening the adjustment which would otherwise have been made. However, we have obviously an adjustment of a high degree of precision, carefully matched to the angle of tilting.

But these periods were very short, only six minutes. In ordinary life it is endurance in the standing position which is likely to be followed by circulatory embarrassment. The West Point cadet faints at the long ordeal of inspection, the woman gets dizzy and faint when clothes are being slowly and carefully fitted, people collapse when they wait for long times in slow-moving lines, when they stand in crowds waiting for parades and the like. And these are not all weaklings, witness the West Point cadet or the husky young woman in my first series who played hard tennis daily yet always required a stool near her wall telephone.

Have we evidence that the precise circulatory adjustment first made on the assumption of the vertical position becomes progressively less efficient as quiet standing is prolonged? Our tests have lasted for 15 minutes only but the evidence from each of our many series of experiments is concordant—there is often a progressive shift in the heart rate and a progressive rise in diastolic pressure as standing continues until in a considerable number of young women there comes the sudden slowing of the heart rate and the abrupt fall of systolic and diastolic pressures, the onset of syncope. These young women show remarkable similarity in tests of this sort repeated day after day—there is a personal pattern for one's adjustment to gravity, (Turner 1927 b, 1929) and some succeed astonishingly well, with almost no change as standing is prolonged, with no sense of dizziness, no sense of fatigue, while others know that they are likely to be dizzy after a few minutes in the quiet erect position and time after time they are saved from fainting only by reclining hastily. Their personal sensations and the picture of heart-rate and pulse pressure agree—the observer often knows they are about to fail before they feel it. In figures 2, 3 and 4 we have the responses of three young women of different types, each figure the average of several tests made with the cautions indicated in the legend. One was

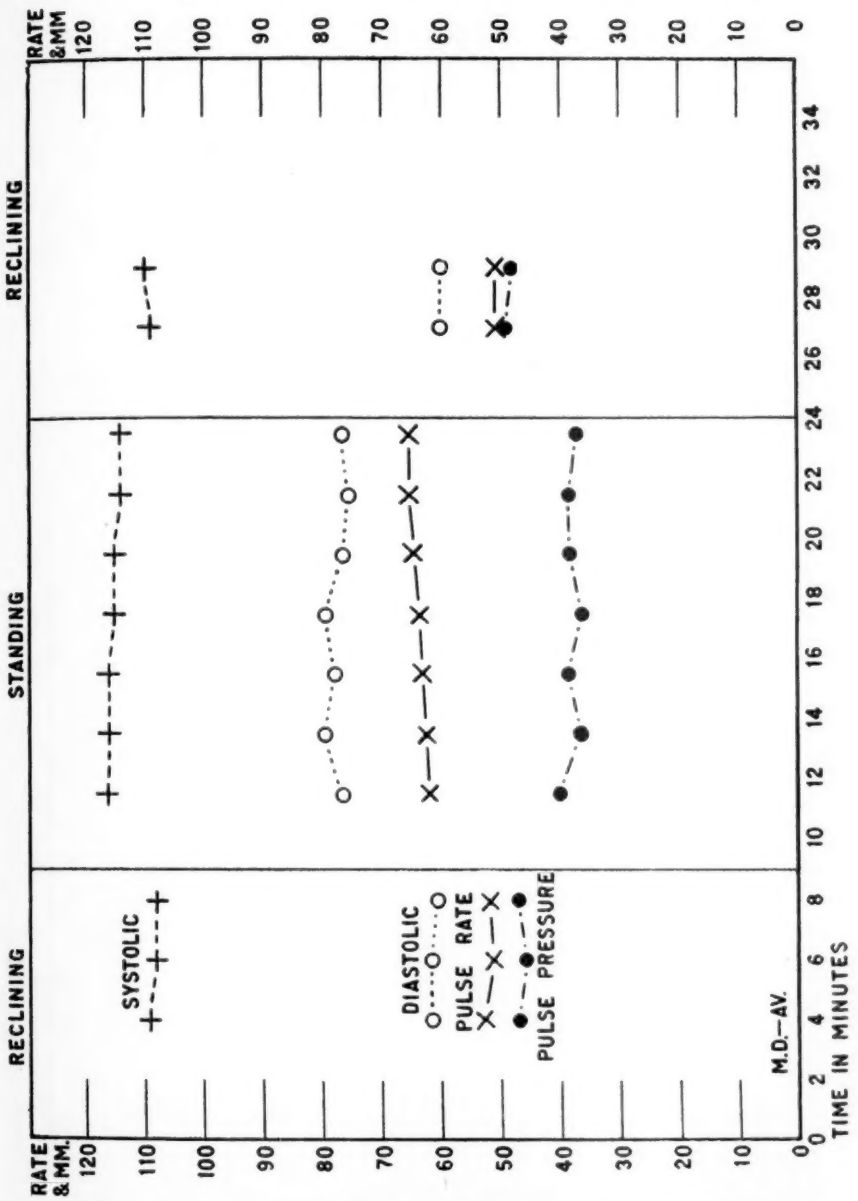

Figure 2. Record of prolonged standing circulatory tests on Subject M.D. Average of 7 tests, all taken at the same time of day, at least three hours after the last meal, with no strenuous exercise in the interim. Preliminary reclining period of 10 to 15 minutes not shown. Dots or crosses indicate individual determinations at time shown in lower margin, in minutes from beginning of record. Heart rate in beats per minute and pressures in mm Hg shown in side margins.

M. D. was an excellent subject. Note small increase in heart rate on standing, wide pulse pressure in standing, systolic rise, and especially the steadiness with which all conditions were maintained during the fifteen minutes of standing.

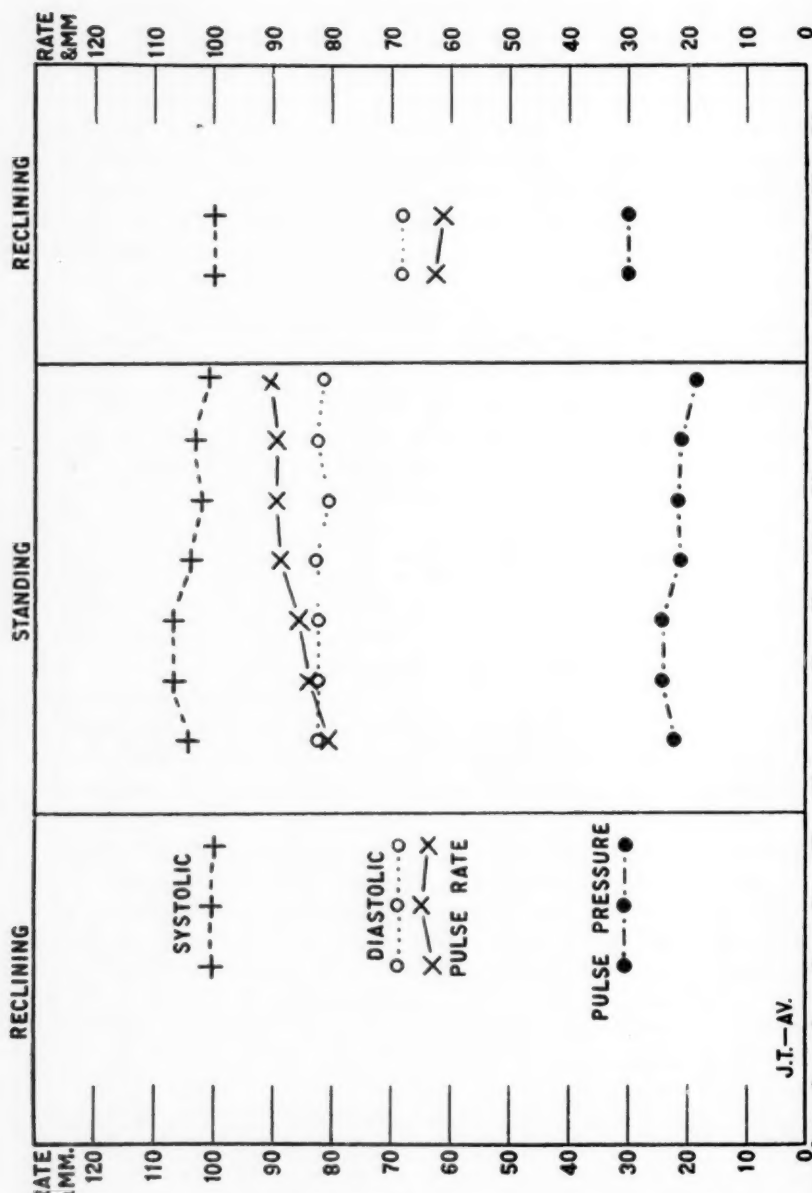

Figure 3. Same kind of record as in Figure 2. Subject J. T. was only moderately successful in standing. Note marked and progressive pulse increase on standing, narrow and progressively decreasing pulse pressure, falling tendency of systolic pressure. She was sometimes dizzy.

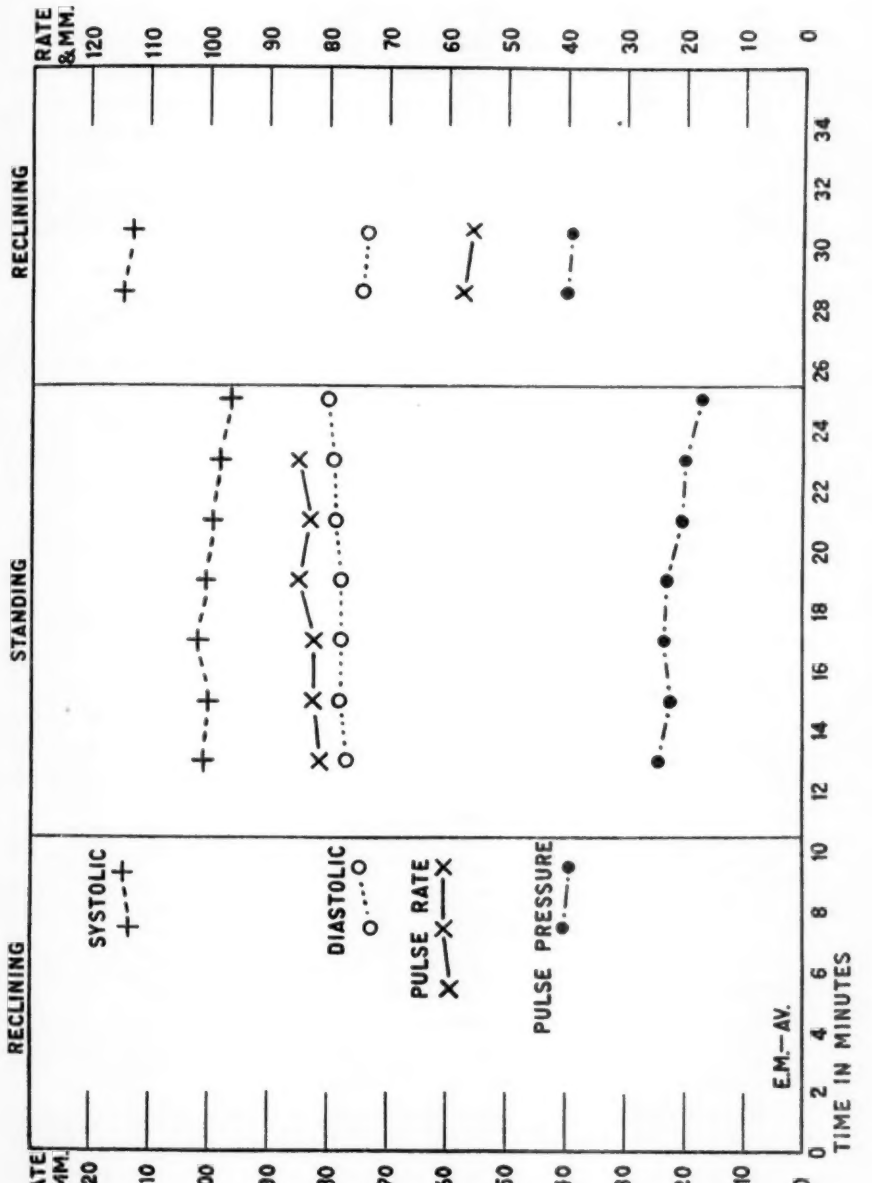

Figure 4. Same kind of record as Figure 2. Subject E.M. was always uncomfortable in standing, though not always acutely dizzy. She sometimes fainted, though not in this series. Note marked systolic fall, and progressive fall in pulse pressure and systolic pressure.

an excellent subject, one was about average in her success, with a gradual shift in her findings as time passed, the third was a poor subject, always uncomfortable when standing and several times obliged to give up and lie down before the fifteen minutes of the standing period had ended. We have then the picture of successful standing with a heart rate only moderately accelerated over the reclining rate, with a pulse pressure kept wide and steady, showing an abundant return of blood to the heart and hence a good supply to the medullary centres. When the rate rises high we have, as Schneider (1921) so well says, a symptom of distress, and in the increasingly narrowed pulse pressure the last effort at vasoconstriction to compensate for the small volume of available blood.

Another question is this: if, as has been thought, the blood has difficulty in getting back to the heart in prolonged quiet standing, can we find evidence of the place of its stagnation?

There has been conclusive evidence for many years that the circulating liquids tend to stagnate in the feet and legs when the circulation becomes even slightly impaired. A mention of swollen ankles and varicose veins is sufficiently suggestive. We have tried to find out in our laboratory (Turner, Newton and Haynes) whether such states are foreshadowed in *healthy* young women by having them stand quietly in a can of water for fifteen minutes. The water is of such temperature that it feels neither warm nor cool. The heart rates and blood pressures under these conditions are indistinguishable from those of control tests, similar in all respects except that the subject stands on the floor as usual. The relation of subject to can is shown by Figure 5 in which is also shown the gauge which is read just after the subject steps in and just before she steps out. In one set of experiments, in the winter, the rise in fifteen minutes was 175

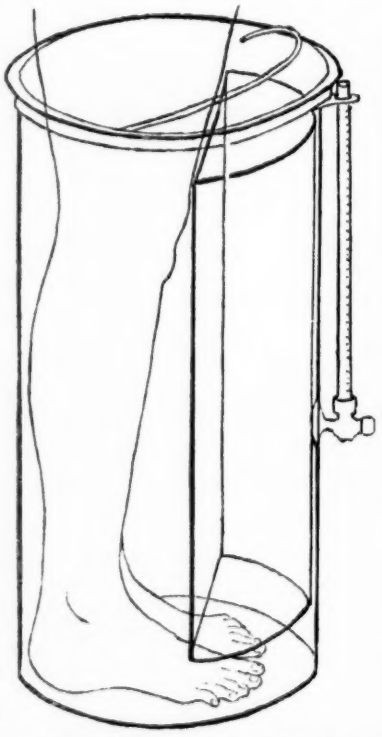

Figure 5. Position of subject in can of water. Inner can lessens total volume concerned and hence increases vertical rise in gauge.

cc, in a summer series it was 256 cc. See Table 1. These are quantities which attest real stagnation though they are of such an order of magnitude that it would seem an easy thing for the circulation to make suitable compensations.

The favorite hunting ground for circulatory stagnation is of

TABLE 1

Changes in leg volume induced by standing for 15 minutes in a can of water of neutral temperature. Series A in winter, 35 experiments on 20 subjects. Series B in summer, 6 experiments on 4 subjects. Average values. The greater peripheral blood supply in summer is suggestive.

	Temperature of bath	Leg volume in cc.	Increase in leg volume in cc.	Per cent increase in leg volume
Series A	30.2	9,149	175	1.90
Series B	31.15	7,260	256	3.36

course the splanchnic region. (Hill, 1895; Hill and Barnard, 1897; Crampton, 1913, 1915; Sewall, 1916, 1919). Experiments (Turner, Newton and Haynes) planned to reflect the significance of this area in healthy young women were done by having the subject go through the usual standing test and then follow this by a similar test with her abdomen well supported by a broad ACE bandage. The results are shown by Figure 6 which gives a graph of a typical experiment and by Table 2 which summarizes our results. It is seen that the bandage means a decreased adjustment in both heart rate and pulse pressure; in other words, the bandage seems to prevent stagnation and this bettered return of blood to the heart lessens the need for modification of rate and pressures. This abdominal stagnation seems to be of considerable magnitude, judging by these changes in heart rates and

TABLE 2

Effect of abdominal support on circulatory findings in prolonged standing. Broad ACE bandage used. 13 experiments on 13 subjects. All figures are averages from minutes 3-15 of standing compared with a control reclining period after standing. In no experiment did the characteristic result fail to appear in either heart rate or pulse pressure or both. In a second series with various supports the same results were obtained. Figures are beats per minute and mm Hg except where percents are indicated.

	Without support				With support			
	Reclining	Standing	Change	Change %	Reclining	Standing	Change	Change %
Heart rates	58.0	87.7	+29.5	+50.9	57.2	80.6	+23.4	+40.9
Pulse pressures ..	35.2	25.2	—10.2	—29.0	37.7	28.2	— 9.5	—25.2

pressures, and probably accounts for much of the change usually seen in the ordinary standing tests.

Another line of evidence comes from comparing the standing reaction before and after dinner. (Turner 1929). We know that a meal tends to raise both the heart rate and the circulatory minute volume so the pictures before and after will not be identical. When the comparative ability to maintain an adequate circulatory adjustment in 15 minutes of quiet standing was tried out it was found

that with one accord the young women seemed better able to stand after than before dinner. They said too, that they stood more comfortably. One habitually poor subject who had always been dizzy before dinner (at which time her tests had been done in a routine way) was delightfully comfortable to the end of her fifteen minutes of standing after dinner. Another who could stand not more than six or eight minutes without acute dizziness stood easily after dinner for the whole fifteen. The reason seems not far to seek, in the swifter movement of blood through the splanchnic circuits, and in the movements of the digestive tract which give as it were effective massage to the blood in its vessels, thus returning it to the heart in larger amounts, so that the medullary centres benefit as well as the digestive organs.

The ideally efficient circulatory apparatus would always deliver enough blood for the activity or position in question. How are we to know whether a given young woman has such an apparatus? Many have tried to devise tests of circulatory efficiency (Schneider, 1920, 1923; Crampton, 1913, 1915; and many others). There is real need to know whether the typical programs now in use in our departments of physical education are training not merely the neuro-motor coordinations and the personality of the individual in his relations to his group, but whether we are doing the best we can to make dependable and secure the performance of those functions of the body so fundamentally important and so pathetically often the cause of years of limitation and ultimate death, the respiration and the circulation. In general we have been wont to think that the results are good—but how much do we *know?* This problem of major importance surely presents many questions still unanswered—there is *no* adequate test of circulatory efficiency, great as the need is by physical educators, the medical profession, life insurance companies, and keen as is the interest of many physiological laboratories in finding the picture of the circulatory adjustments in health. As a small indication of progress in this last line, as an indication that the excellent circulation must have as one of its powers a successful response to gravity as well as to exercise, this paper is presented. Its findings are far from complete, but work will continue along the lines which are suggested. We hope that those who follow us may at length be able to say that a certain type of physical training is right for making an inefficient circulatory apparatus not only more perfect in its performance for a brief period, but more able to stand the assaults on its integrity made by our complex life activities and habits. It is only by a clearer understanding of the normal individual that we may hope to lessen the tragic number of circulatory failures. To whom do such problems more truly belong than to the group of physical educators?

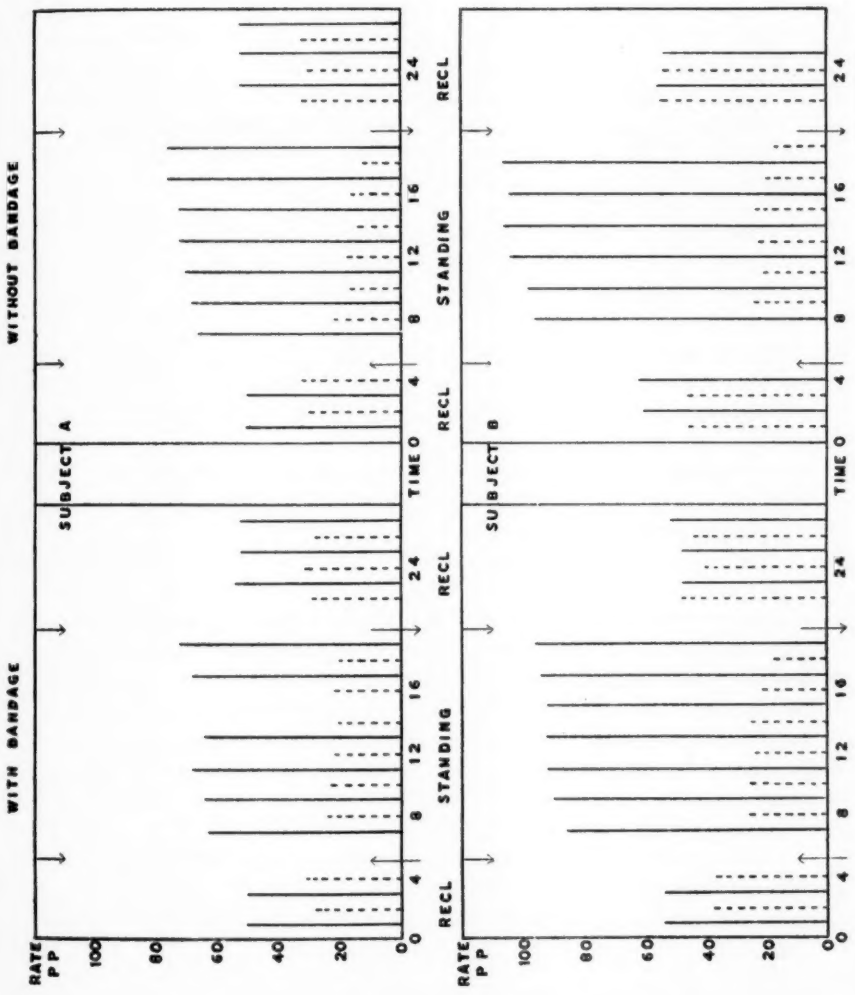

Figure 6. Records of two pairs of standing experiments with and without abdominal bandage. 15 minutes of preliminary reclining not shown—it preceded each test. Abscissae, time in minutes from beginning of test. Ordinates, heart rate in beats per minute and pulse pressures in mm Hg. Continuous lines, heart rates; dotted lines, pulse pressures. Arrows indicate beginning and end of standing period. Recl., reclining.

Subject A, a young woman of slow heart rate and small pulse pressure. Subject B, of rapid heart rate standing and much wider pulse pressure. Note that the change in response due to the bandage is the same for both, though picture of circulation and response without bandage are characteristically different in the two.

SUMMARY

A study has been made of the reaction to gravity shown by the circulatory apparatus of healthy young women. A comparison of the oxygen consumption in the erect position and in exercise shows that a very slight circulatory adjustment would account for the increased need of the erect as contrasted to the reclining body for oxygen, whereas an extensive circulatory adjustment is found. It is thus not the *work* of standing which causes this adjustment. When young women are tilted to various angles this adjustment of increased heart rate and narrowed pulse pressure (due to diastolic rise) is found to be very precise with a clearly marked and progressive response to angles of 15, 30, 45, 60, 75 and 90 degrees. This is for periods of only six minutes in each position. When however the young woman stands still for a period of 15 minutes it is found that only the exceptional individual can maintain her first adjustment steadily and successfully, the majority show a progressive increase in heart rate and narrowing of pulse pressure as time passes, while the poor group carries this to extreme and then shows the slowed heart and rapidly falling systolic and diastolic pressures of dizziness and syncope. The reactions of a given individual under constant conditions tend to be characteristic and predictable.

A reason for the progressive change in the erect position seems to lie in a diminished return of blood to the heart due to the pull of gravity, for which there is evidence in the results of studies on circulatory minute volume (though other workers find no decrease). Evidence for stagnation under ordinary circumstances is found in the increase in the size of the legs as quiet standing is continued and in the bettering of the reaction to gravity induced by a snug abdominal bandage. Evidence also comes in a better standing reaction after a hearty meal at which time we know the vigor of the blood flow through the digestive tract to be increased.

The importance of the relation of physical education programs to circulatory success is suggested.

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A Study of the Physical Efficiency of College Women As Shown by the Pulse-Ratio Test

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IT is evident that up until recent years there has been a much keener interest in the physical fitness of men than women. Such an attitude is quite apparent since practically all interscholastic contests and expenditures for athletic purposes have been for men.

The benefits derived from systematic physical training are now being recognized among women as well as men. We also find an increase in provisions for supervised physical education where there are organized groups of women. The recent universality of this recognition has brought forth a rapid development of specialized departments for such training. In addition to the attempts being made to teach methods for organizing and carrying out desirable sports for women much interest in the scientific attack on physical education is being shown.

In attacking the problem of physical efficiency of women, we meet in general the same situations that are found among men. However, the physiological differences between men and women necessitate a variation in the procedure of investigation.

In this investigation an attempt is made to throw some light on the problem of physical efficiency of women by a comparison of data procured by the pulse-ratio test given to different groups. Certain phases of the problem deal with phenomena which are characteristic of women.

The problem of physical efficiency of women is attacked in the same manner as in the case for men, although specifically some of the problems investigated apply only to women. The problems considered in this study are as follows:

1. A comparison of the physical efficiency of women who smoke with those who do not.
2. A study of the part temperament plays in physical efficiency.
3. The periodic fluctuation of physical efficiency during the menstrual cycle.
4. A comparison of the physical efficiency of women who participate in athletics with those who do not.
5. A study of the effect of fatigue on physical efficiency.
6. A study of the uniformity of physical efficiency of women.

The problem of physical efficiency has been attacked from almost

every angle. However, much of the work is based on the compensatory mechanism of the cardio-vascular system. A complete review of the literature is necessarily omitted on account of its voluminous nature. Reference is made to those investigations which have a direct bearing on the problem under investigation.

McCurdy,[1] in searching for a "norm of vigor," studied the heart rate and blood pressure of adolescent boys. These were compared in the reclining and erect positions. He found there was a wide variation in beats per minute. He also noticed that, in general, the older the child physiologically, the lower the heart rate. The same principle holds true for chronological age with the exception of the ages 13 and 14, when the child is passing through the most critical period of pubescence.

Crampton,[3] who believes it a fair presumption that the heart action is a good index to physical efficiency since the distribution of blood depends upon it, presents the following rating measure: a comparison of the heart rate and blood pressure with the subject in an erect and reclining position. A variation of 0 to 44 beats per minute was found, while the systolic blood pressure ranged from minus 10 mm. Hg. to plus 10 mm. Hg. When blood pressure tended to fall, the heart rate was accelerated in all cases except those "not feeling very fit." In these cases there was a good pulse-rate increase with a large fall in pressure.

Conrad[8] studied the reaction of the heart under conditions of strenuous exercise. Irregularity and tone were noted. He concluded that if the heart reacted normally after strenuous exercise irregularities and murmurs were of little significance.

The fact that the heart rate of trained athletes is slower than the untrained has attracted much attention. Starling[4] accounts for this by saying that the output of blood per heart stroke is greater in the trained individual.

Foster[6] assumes that the increase in heart rate after exercise is proportional to the amount of work done. His method of investigation picks out the individuals with a heart showing a high frequency after mild exercise. The technique is to record the normal standing pulse for one minute, after which the subject runs in place for 15 seconds at the rate of 180 steps per minute. The pulse rate is then taken for 15 second periods and recorded for one minute. After the subject stands at rest for 45 seconds the pulse rate is again recorded for one minute. A comparison of these data shows that the return to normal occurs between the first and second minute after exercise.

Meylan[9] noted the tone and rhythm of the heart in both the prone and upright position. The heart reaction to exercise was recorded for four 15 second periods after the subject had hopped a distance of

[1] See bibliography at end of article.

100 feet. Meylan considers a retraction of 80 per cent of the gain produced by the exercise from the first to the second 15 second period after exercise as a possible sign of efficiency.

In the study made by Campbell[7] we have attention called to the fact that increasing pulse-rate with increasing weight is applicable to nearly all mammals. He also cites the fact that pulse rate in women is on the average ten beats faster than in men and that this difference can be noted at any age after seven.

Campbell assumes that a high pulse-ratio is a reliable sign of unfitness. However, where the resting pulse rate is high in case of the unfit the test may give an artificial advantage by minimizing the effect of the greater increase in heart rate of trained and untrained athletes. Their data show that the greatest difference in fall of the heart rate occurs during the second half minute after exercise.

Hartwell and Tweedy[8] studied the normal heart rate of women. They found that in non-athletic women the rate was 78 while for athletic it was 76.

Barach[9] suggests a method for determining the functional capacity of the heart. The systolic pressure is considered as the energy factor in the work of the heart and the diastolic pressure as the energy factor in peripheral resistance. In order to find the energy expended the sum of the systolic and diastolic pressures is multiplied by the heart rate. This method would apply only to a resting heart.

Barringer[10] investigated the circulatory reaction to graded work as a test of functional capacity. He administered dumb-bell and bicycle ergometer exercises to both normal subjects and those having cardiac insufficiency. In case of the normal subjects there was a marked rise in systolic pressure and pulse rate. In subjects with a cardiac insufficiency there was only a slight rise in blood pressure as the work became more intense, and frequently it dropped below normal.

In attempting to find a reliable measure of physical efficiency, Hambly[11] investigated the fitness of 63 men between the ages of 16 and 39 years. In the beginning he classified this group into best athletes, very fit, above average, average, below average, and unfit according to his knowledge of their physical condition. For the purpose of finding an index that would coincide with the fitness of the various groups, experiments were carried out in blood pressure, pulmonary ventilation, vital capacity, manometer tests, holding the breath, weight, stem length and height, girth of chest, and pulse-ratio.

The results obtained by Hambly led him to conclude that the pulse-ratio test was the best index to physical efficiency.

In a more recent report Pembry[12] presents more data showing the reliability of the pulse-ratio test as an index to physical efficiency. In developing the technique various types of light exercise were used. The final technique adopted is as follows: the subject steps on and

off a stool 13 inches high for three minutes. The ratio is found by dividing the pulse rate for two minutes after exercise by the resting pulse for one minute. The use of this test indicated that the pulse-ratio after mild exercise is a good index to physical efficiency.

In general the technique employed in this investigation is the same as that used by Hambly and Pembry. The standard work consists of stepping on and off a stool 13 inches high at a uniform rate for a period of one minute. The amount of work done is varied by changing the rate of performance and is expressed in "number of steps per minute."

For the purpose of comparing the data, the amount of work required to produce a pulse-ratio of 2.5 is adopted as a standard. This figure is obtained theoretically. The method consists of selecting two rates of stepping, one giving a pulse-ratio less and one greater than 2.5. In this experiment the former rate is 15 and the latter 30 steps per minute. By plotting the 15 steps on the abscissa and the resulting pulse rate on the ordinate against the 30 steps on the abscissa and the resulting pulse rate on the ordinate, one can, by connecting the two points, determine the number of steps required to produce a 2.5 ratio. This figure is found by dropping an ordinate from the point where the line connecting the two points just described crosses the 2.5 abscissa. Figure 1 shows in detail how the calculations are made.

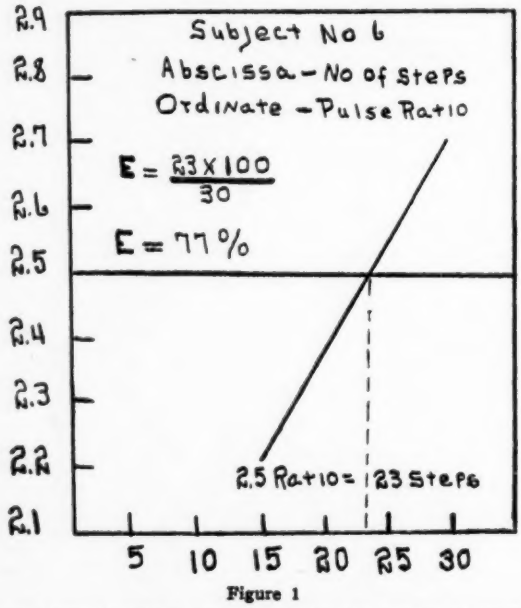

Figure 1

This figure shows the method used in finding the number of steps required for a 2.5 pulse-ratio.

For the sake of convenience in presenting the data, the efficiency expressed in "number of steps" are changed into percent. This is done as follows: it is assumed that any subject who requires 30 steps to produce a pulse-ratio of 2.5 is 100 per cent efficient.

By applying the formula $\frac{\text{No. steps required for 2.5 ratio} \times 100}{30}$

per cent efficiency is obtained.

The data presented under the different groups studied are presented under the appropriate headings. For the sake of brevity the raw data are omitted and only the results of the experiment presented.*

A Comparison of the Physical Efficiency of Girls Who Smoke with the Efficiency of Those Who Do Not

In this experiment ten women who smoke habitually and ten total abstainers were picked at random. The data show that the mean pulse rate of the smoking group is 84.8 beats per minute while for the non-smokers it is 81.9.† The observed difference is 2.9 beats per minute. The mean efficiency rating of the smoking group is 72.9 per cent while the abstainers have an efficiency rating of 86.2 per cent. Here the observed difference is 13.3 per cent. The data indicate that the non-smoking group have a slower heart rate and a distinctly higher physical efficiency. The data are too meager to be considered other than showing a general tendency in the direction indicated.

A Study of the Part Temperament Plays in Physical Efficiency

Much has been said concerning the "temperament" of women in its relation to athletic performance. The nervous, excitable, irritable girl is usually considered less efficient in sports. No doubt men are not immune to such tendencies but Williams[33] has shown quite conclusively that such tendencies are more characteristic of women than men.

The group considered as temperamental was chosen on a basis of previous association of one of the writers. Those observed to be consistently excitable and nervous were placed in the temperamental group. Those recognized as being calm and steady in their reactions under normal and unusual situations were placed in the non-temperamental group.

Data were collected from 20 women, ten representatives of each group. The data show that the mean normal pulse rate of the "calm" group is 86.3 beats per minute and of the "temperamental" group

* The complete data are in published form and are on file in the library of the State University of Iowa.

† The data are not subjected to other statistical treatment in this study as the cases are too few in number.

89.4. The observed difference is 3.1 beats per minute. The mean efficiency rating of the "calm" group is 82.8 per cent and of the "temperamental" group 87.8 per cent. The observed difference is five per cent. The data indicate that the pulse rate of the "calm" type is less than that of the "temperamental" as is also the case with their efficiency. The concensus of opinion is contrary to these efficiency findings. The data are too meager to draw conclusions but since the "calm" type possesses the lower heart rate, it is suggested that they did not, in this case, overcome the false advantage gained by the "temperamental" group, by the faster pulse rate. No doubt, this problem needs further investigating since subjective data were used as a criterion of temperament. This part of the investigation is included only for the purpose of stimulating further consideration of the problem of "temperament" in physical education.

The Periodic Fluctuation of Physical Efficiency During the Menstrual Cycle

Just how the reactions of women vary during the menstrual cycle has not been conclusively demonstrated. In practically all cases the variation in the reactions seem to depend on the condition of the subject during menstruation. In order that each phase of the period might be observed data were collected according to the division of time based on Howell's[4] classification. This consisted of a test three days before, thus falling in the period of growth which is given as five days preceding the beginning of flow. The second test came during the period of flow. A third test was made three days after the cessation of the flow, falling within the five day period of regeneration. For a record during the period of rest a test was given 12 days after the cessation of menstruation.

Data were collected from nine normal women over a period of three months. Due to impossibility of access to some of the group and the inability to determine the third day preceding the beginning of flow, some data are necessarily lacking. The data show that the mean resting pulse rate for each subject is practically constant throughout the series of experiments. The mean efficiency rating for the group during the pre-menstrual period is 95 per cent, during menstrual 94 per cent, the post-menstrual period 87 per cent and during the period of rest 90 per cent.

The data indicate that during the pre-menstrual period and the period of flow the physical efficiency rating is higher than during the periods of regeneration and rest.

A Comparison of the Efficiency Ratings of Women Who Participate in Athletics with the Efficiency of Those Who Do Not

At the present time there are some who question the advisability of women participating in athletics. In order to throw some light on

this question the physical efficiency ratings of 86 girls participating in competitive athletics are compared with the efficiency ratings of 90 women who take no part in athletics. The data show the following:

	Mean	Standard Deviation
Athlete	91.9±1.62	27.60
Not-athlete	85.7±2.16	22.88
s diff.	=3.83	
P. E. diff.	=2.58	
Critical Ratio	=2.41	

The comparison of the data indicate that there are 95 chances in a hundred that the athletic women have a higher efficiency rating than the non-athletes. The writers feel that this prediction is somewhat high due to the fact that the standard deviation is large. However, the tendency is no doubt authentic.

A Study of the Effect of Fatigue on Physical Efficiency

This problem is attacked from two angles: first, fatigue produced experimentally in the laboratory and, second, fatigue brought about by the daily routine of activities.

In the first part of the experiment five normal women were used as subjects. The subjects were brought into the laboratory and allowed to rest for a time. At the end of the rest period an efficiency rating was made. Following this, each subject performed 250 deep knee bends in groups of 50 with two minutes rest between each group. Immediately after the exercise, each subject rested for 30 minutes. At the end of this period a second efficiency rating was recorded. The data show that the mean normal standing pulse before exercise is 80 beats per minute while 30 minutes after exercise it is 92.2. The mean efficiency rating before exercise is 93 per cent and after exercise it is 70.8 per cent. The observed difference in pulse rate is 12.2 beats per minute and in efficiency 22.2 per cent. The data reveal the fact that fatigue materially accelerates the normal heart rate and decreases the physical efficiency rating.

Ten normal women were used as subjects for the second part of the experiment. The physical efficiency of the group was recorded at 8:00 A. M. and 10:00 P. M. In the morning the mean normal standing pulse rate was 81.7 with an efficiency rating of 85.6. In the evening the mean pulse rate was 84.4 and the efficiency rating 80.6 per cent. This part of the investigation shows the same tendencies as the laboratory experiment except that the results are not so pronounced. These data are further evidence that fatigue accelerates the normal heart rate and reduces physical efficiency.

A Study of the Uniformity of the Efficiency Rating of Women

The object of this experiment is to determine how much the physical efficiency ratings fluctuate over a period of time. Nineteen nor-

mal women were used as subjects. The only control of conditions was that the tests were given during the "rest period" of the menstrual cycle. The plan of the experiment was to make the efficiency ratings each month over a period of six months. In most cases, however, unforseen circumstances necessitated the omission of some of the data. The consistency of the efficiency ratings is best shown by the mean deviations which are shown in the following table:

Subject number	Mean per cent	Mean deviation per cent	Subject number	Mean per cent	Mean deviation per cent
1	103	15	11	72	9
2	84	4	12	71	11
3	78	10	13	79	9
4	82	13	14	83	10
5	83	12	15	72	19
6	92	9	16	96	21
7	73	10	17	50	0
8	85	22	18	84	11
9	86	14	19	88	8
10	67	13			

The data in the preceding summary show that, in fourteen of the nineteen cases, the mean deviation over a period of six months is 9 to 15 per cent. The irregularity of the other five cases deserves special comment. Subject 2, who showed a mean deviation of only four percent, is a very athletic type of woman who trains rather consistently. It is interesting to note that her greatest deviation from the mean is only sixteen per cent. Subject 8 shows a mean deviation of 35 per cent. The irregularities of the efficiency rating of this subject are not apparent from the data at hand. Subject 15 is also of special interest. Up until February she took no active part in athletics. She then became active in basketball and played regularly through the season. The data presented show the efficiency rating of this subject to be low until she became interested in basketball, the mean being 53 per cent. From February on through the experiment the efficiency ratings were materially improved. The mean was increased to 90 per cent for this period. Subject 17 was found to have a very low normal heart rate with the response to exercise quite great. Fifteen steps in each case gave a ratio of 2.5 or above, making her efficiency rating 50 per cent. This may partially be explained by the disadvantage of a low normal pulse in these tests. However, the status of the physical condition was not available, and no attempt is made to explain the consistent low efficiency rating.

The conclusion which seems justified from this part of the investigation, is that normal individuals who are subject to a routine daily life and who pay no particular attention to systematic training, vary in efficiency from 9 to 13 per cent. Where the variation is greater or less than this figure there appears to be some special circumstance which accounts for it

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CONCLUSIONS

The following conclusions have been drawn from the data collected:

1. A comparison of the groups used in this investigation shows that women who smoke are at a distinct disadvantage in physical efficiency as compared with those who do not. They have a higher normal standing pulst-rate.

2. Temperamental women considered in this study have a higher normal standing pulse and show a higher physical efficiency than the calm individual.

3. The normal heart rate during the menstrual cycle showed a relatively constant count. The individual is most efficient physically during the period of endometrium growth and the menstrual flow. They are less efficient during regeneration with a rise in efficiency during the period of rest.

4. Athletic women show a slower normal heart rate and have a higher physical efficiency than the non-athletic type.

5. Fatigue increases the normal heart rate and lowers the efficiency of the individual.

6. The variation in physical efficiency ratings which one may expect in the normal individual from time to time will fall between nine and fifteen per cent.

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Nomographs for Interpolating Scores on the Schneider Test

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In connection with some recent experimental work[1] involving graphic pulse recording, the well-known Schneider Test[2] of cardio-vascular efficiency was given by the author to a number of subjects, to some once and to others twice. Although the records thus obtained were not sufficiently numerous to justify extensive statistical manipulation they were, naturally, examined for some of the more obviously interesting relationships, among them the comparison between the two records of the same person. This comparison revealed what appears to be an internal defect in the scoring system. In the following paragraphs an attempt is made to make this defect clear and a correction is suggested.

Since the present article is a discussion of the Schneider Test *scoring tables* and would have little meaning to a reader who did not have the tables at hand, it seems wise to risk unnecessary duplication by reproducing them here:

TABLE I

Schneider Test: Points for Grading Cardio-vascular Changes

A. Reclining pulse-rate		B. Pulse-rate increase on standing				
Rate	Points	0-10 beats, points	11-18 beats, points	19-26 beats, points	27-34 beats, points	35-42 beats, points
50- 60	3	3	3	2	1	0
61- 70	3	3	2	1	0	—1
71- 80	2	2	2	0	—1	—2
81- 90	1	2	1	—1	—2	—3
91-100	0	1	0	—2	—3	—3
101-110	—1	0	—1	—3	—3	—3

C. Standing Pulse-rate.		D. Pulse-rate increase immediately after exercise				
Rate	Points	0-10 beats, points	11-20 beats, points	21-30 beats, points	31-40 beats, points	41-50 beats, points
60- 70	3	3	3	2	1	0
71- 80	3	3	2	1	0	—1
81- 90	2	3	2	1	—1	—2
91-100	1	2	1	0	—2	—3
101-110	1	1	0	—1	—3	—3
111-120	0	1	—1	—2	—3	—3
121-130	0	0	—2	—3	—3	—3
131-140	—1	0	—3	—3	—3	—3

[1] This work, of which the present paper is a by-product, was done under the direction of Professor Howard E. Hamlin of the Department of Physiology, Ohio State University, and the Summer School of Physical Education, Harvard University.

[2] The test was first described in:
Schneider, Edward C.—"A Cardio-vascular Rating as a Measure of Physical Fatigue and Efficiency," Journal American Medical Association, May 29, 1920, p. 1507.
Later in:
Schneider, Edward C.—Military Surgeon, Jan. 1923.
Excellent descriptions can be found in:
McCurdy, J. H.—The Physiology of Exercise. Lea and Febiger, 1924, pp. 214-216.
Morrison, Whitlaw Reid, and Chenoweth, Laurence B.—Normal and Elementary Physical Diagnosis. Lea and Febiger, 1928, Chap. XXI.

E. Return of pulse-rate to standing normal after exercise

Seconds	Points
0-60	3
61- 90	2
91-120	1
After 120: 2-10 beats above normal	0
After 120: 11-30 beats above normal	—1

F. Systolic pressure, standing, compared with reclining

Change in mm.	Points
Rise of 8 or more	3
Rise of 2-7	2
No rise	1
Fall of 2-5	0
Fall of 6 or more	—1

To obtain a subject's rating on the test the operator secures, under standardized conditions, measures for the six factors A, B, C, D, E, and F, named in the tables. He then consults the tables and reads a score for each factor. It must be noted that the score for B (pulse-rate increase on standing) depends not upon the increase alone, but also upon the reclining pulse rate; e.g., a given increase from one reclining rate may score three points, the *same increase* from a different rate, two points. A similar remark applies to factor D. The six component scores added algebraically give the subject's rating, which theoretically may be any integral number from +18 to —10, inclusive.

Now on the records referred to in the first paragraph the first name was that of Beard. Beard's rating was seven points on May 15, but thirteen points at the same hour on May 27, the readings and scores being as shown in Table II.

TABLE II. BEARD'S SCORES[3]

	May 15		May 27	
	Reading	Score	Reading	Score
A. Reclining Pulse Rate	81	1	79	2
B. Pulse-rate increase on standing	12	1	10	2
C. Standing pulse rate	93	1	89	3
D. Pulse-rate increase after exercise	16	1	16	2
E. Time for return to normal after exercise	120	1	120	1
F. Systolic pressure increase on standing	6	2	8	3
		Rating=7		Rating=13

It seems that the Schneider ratings indicate a greater difference than actually existed in the condition of the subject on the two dates. An even greater discrepancy is seen in the hypothetical case of Table III.

TABLE III.

SCORES FOR HYPOTHETICAL SUBJECTS

	Subject A		Subject B	
	Reading	Score	Reading	Score
A. Reclining pulse-rate	90	1	91	0
B. Pulse-rate increase on standing	18	1	20	—2
C. Standing pulse-rate	108	1	111	0
D. Pulse-rate increase after exercise	20	0	21	—2
E. Time for return to normal after exercise	30	3	31	2
F. Systolic pressure increase on standing	8	3	7	+2
		Rating=9		Rating=0

Here are two persons for whom the significant factors are identical within the limits of errors of observation, but whose ratings are

[3] The pulse-rates in this table were taken from graphic records.

as divergent as 9 and 0. The explanation of this fact is rather obvious: the scores in the tables are not continuous but discrete, increasing by jumps of one, two, or even three. If one reading happens to be just below the change point and another just above it, the readings will be nearly the same, but the corresponding scores will differ by the whole increment. Thus a reclining pulse-rate of 70 scores 3 points; one of 71, 2 points; a standing pulse-rate of 90 scores 2 points; one of 91, 1 point. Moreover, in tables B and D this effect may be compounded. If for one subject the reclining pulse-rate and the increase on standing happen both to be just below the change point, and for another subject both just above, then the scores *for B alone* may differ by three points; and similarly for Table D. Thus, Jones with a reclining rate of 80 and an increase of 18, scores 2 points on A and 2 on B, or 4 for A and B together; Smith with a reclining rate of 81 and an increase of 19 scores +1 point on A and —1 on B, or zero for A and B together. In this case trifling differences in pulse rates are responsible for a very large difference in scoring. In the hypothetical scores compared in Table III this principle applies to all six factors; i.e., for subject A each reading is the largest one for the score given, for subject B each reading is the smallest for the next higher score.

Of course such an extreme case as this one is very unlikely to occur in actual practice. It is much more to be expected that the effect described will be self-neutralizing, being high for one factor and low for another, so that a person will be given a rating that is practically correct. But it will not always be so; in a large group there will be many cases with significant errors, and a few cases with errors that are quite large, probably so large as to make the ratings entirely misleading. And it is not possible for one in this case to explain the errors away like a statistician by stating that he is dealing only with groups and not with individuals.

Since the trouble here referred to is due to sudden changes from one unit score to another, the obvious remedy is to eliminate the sudden changes and to substitute gradual ones, in other words to interpolate fractional scores between the integral scores. Let scoring-table A (in Table I) be used for illustration. Here the score 2 is assigned, not to one pulse-rate, but to any pulse-rate in the interval 71-80 inclusive; and likewise the score 1 is assigned to the interval 81-90 inclusive. In order to interpolate, one must assign the scores 2 and 1 to some exact pulse-rates, and the most logical ones are those at the mid-points of their respective intervals. The actual mid-points are probably 75.5 and 85.5, but it will serve the present purpose better and probably be just as accurate to call them 75 and 85. Now if the score for a rate of 75 is 2 points and for one of 85 is 1 point, what is the score for a pulse-rate of 80? By arithmetical interpolation it is 1.5. Similarly the score for 77 is 1 plus .8 of 1, or 1.8; or, inter-

polating the other way: 2 minus .2 of 1, or 1.8. This very simple process could be applied to the Schneider scores by all of the readers of this article without any help were it not for the fact that in tables B and D one must use compound interpolation; he must interpolate in two directions at the same time. An example is the score for Table B when the reclining rate is 73 and the increase is 24. Such scores can be computed without difficulty, but are time-consuming and liable to error. Probably the most satisfactory way to determine them in practice is by the use of nomographs or abacs which record them graphically. Two such graphs have been constructed, one for Table B, the other for Table D, and are here presented, in Charts I and II.

A short explanation will be given of the method of constructing Chart I, that of Chart II being the same. As has already been explained the assumption is made that a score assigned to an interval applies exactly only to the mid-point of the interval. Accordingly, in Tables A and B the interval values given were replaced by their mid-point values, the true values being taken except that, for the sake of consistency, the mid-point of 50-60 was taken as 55.5 and that of 0-10 was called 6.5.[4] Now co-ordinate axes were drawn, and on the X-axis was laid out a scale for the scoring values —3 to +3, on the Y-axis the reclining pulse-rate values 50 to 110. From these axes were located the mid-point values of B (pulse-rate increase on standing). Thus at the point located by +3 on the horizontal scale and 55.5 on the vertical scale a spot was made, and marked 6.5 and also 14.5; at 2 on the horizontal scale and 55.5 on the vertical scale a spot as marked 22.5. Similarly, all the entries in the table were located, the result being a number of spots, several marked 6.5, several 14.5, and so on. These values being located, intermediate values were located by simple interpolation; e.g., having 6.5 and 14.5 the space between them was divided into eight equal divisions and the dividing lines marked 7.5, 8.5, etc. This interpolation was carried on both horizontally and vertically. A sufficient number of points having been located, lines were drawn to connect those of the same value. As the chart was actually constructed the diagonal lines were drawn only for integral values, the fractional values being disregarded. When the horizontal and vertical lines were filled in the chart was completed. In order to extend the chart below 55.5 or above 105.5, or to add diagonal lines below 6.5 or above 38.5, certain assumptions had to be made; their nature will be apparent from a glance at the chart.

In scoring-tables E and F interpolation is not so necessary nor so applicable, but an attempt has been made to interpolate here to the accuracy of the readings taken in giving these parts of the test. The scores are given in Tables IV and V.

[4] In the revised scores for A and C, as shown on Charts I and II, mid-points of the intervals were taken as whole numbers (55, 65, 75, etc.), and not the true values. In the construction of the nomographs, however, all mid-points were taken at their true values.

TABLE IV. REVISION OF SCORING-TABLE E.

Return of pulse-rate to standing normal after exercise

Seconds	Points
0- 45	3.00
45- 60	2.75
61- 75	2.25
75- 90	1.75
90-105	1.25
105-120	.25

TABLE V. REVISION OF SCORING-TABLE F.

Systolic pressure, standing, compared with reclining

Rise of 8 or more	3.00
Rise of 7	2.75
Rise of 6	2.50
Rise of 5	2.25
Rise of 4	2.00
Rise of 3	1.75
Rise of 2	1.50
Rise of 1	1.25
No rise	1.00
Fall of 1	.75
Fall of 2	.50
Fall of 3	.25
Fall of 4	0.00
Fall of 5	—.50
Fall of 6	—1.00

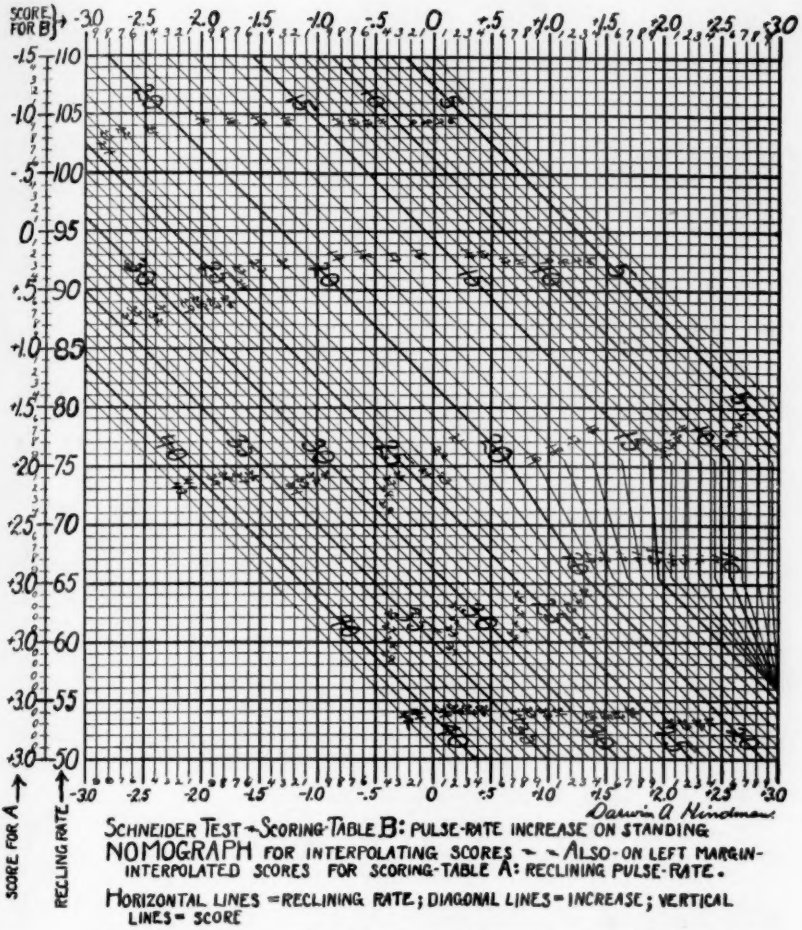
The use of the graphs and tables will now be illustrated by instructions for finding the revised scores for Table II. These scores are entered in Table VI.

TABLE VI. REVISED SCORES FOR BEARD

Compared with original scores

	May 15			May 27		
	Reading	Old Score	New Score	Reading	Old Score	New Score
A. Reclining pulse-rate	81	1	1.40	79	2	1.60
B. Pulse-rate increase on standing	12	1	1.77	10	2	2.20
C. Standing pulse-rate	93	1	+1.20	89	3	1.60
D. Pulse-rate increase after exercise	16	1	+1.20	16	2	1.60
E. Time for return to normal after exercise	120	1	.25	120	1	.25
F. Systolic pressure increase on standing	6	2	2.50	8	3	3.00
Rating		7	8.32		13	10.25

Turn to Chart I and look for the reclining rate 81 and note that the score is +1.4. Now follow the horizontal line 81 to the right until it intersects the diagonal line for the pulse-rate increase on standing, i.e., the line marked 12. Now note the position on the horizontal scale of this point of intersection. It is a little nearer +1.8 than +1.7 and can be called 1.8 or, as here, 1.77. Now turn to Chart II and look for 93, the standing pulse-rate. Mark down the score +1.2, and follow the 93 line to the right until it intersects the diagonal line 16. Read this point of intersection on the horizontal scale and write down the result, 1.20. Now turn to Tables IV and V and write down the scores for E and F. Let the same process be repeated for the right half of the table (May 27). The result will show quite a diminution in the discrepancy between the two ratings of Mr. Beard. His rating increased, from one test to the other, not 6 points, but 1.93 points.



SCHNEIDER TEST — SCORING-TABLE B: PULSE-RATE INCREASE ON STANDING.

NOMOGRAPH FOR INTERPOLATING SCORES — ALSO ON LEFT MARGIN-INTERPOLATED SCORES FOR SCORING-TABLE A: RECLINING PULSE-RATE.

HORIZONTAL LINES = RECLINING RATE; DIAGONAL LINES = INCREASE; VERTICAL LINES = SCORE

DIRECTIONS: — FIND RECLINING RATE ON SCALE AT LEFT — FOLLOW HORIZONTAL LINE THROUGH THIS POINT TO DIAGONAL LINE REPRESENTING INCREASE — FROM POINT OF INTERSECTION FOLLOW VERTICAL LINE TO SCALE AT TOP OR BOTTOM.

CHART I.

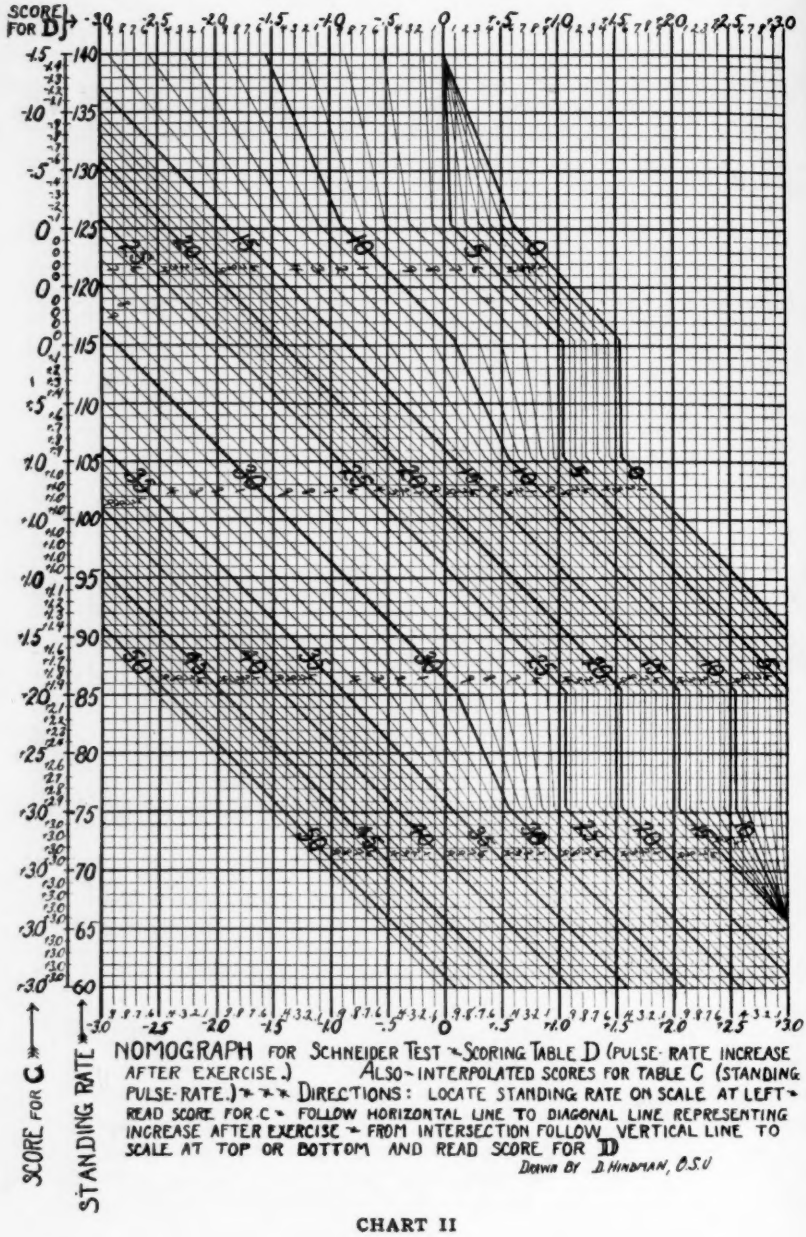

SCORE FOR D
-30 -25 -20 -15 -10 -5 0 +5 +10 +15 +20 +25 +30
SCORE FOR C
STANDING RATE
140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60
NOMOGRAPH FOR SCHNEIDER TEST - SCORING TABLE D (PULSE-RATE INCREASE AFTER EXERCISE.) ALSO - INTERPOLATED SCORES FOR TABLE C (STANDING PULSE-RATE.) - - - DIRECTIONS: LOCATE STANDING RATE ON SCALE AT LEFT - READ SCORE FOR C - FOLLOW HORIZONTAL LINE TO DIAGONAL LINE REPRESENTING INCREASE AFTER EXERCISE - FROM INTERSECTION FOLLOW VERTICAL LINE TO SCALE AT TOP OR BOTTOM AND READ SCORE FOR D
Drawn By D. HINDMAN, O.S.U

CHART II

If the same process is repeated for the hypothetical case of Table III the new scores will compare with the old ones as shown in Table VII. Here again the difference between the two ratings has been diminished very greatly, being less than one-fourth as large with the revised scores as with the original scores.

TABLE VII. REVISED SCORES FOR HYPOTHETICAL CASE

	Compared with original scores					
	Reading	Original Score	Revised Score	Reading	Original Score	Revised Score
A. Reclining pulse-rate	90	1	+.50	91	0	+.40
B. Pulse-rate increase on standing	18	1	—.32	20	—2	—.90
C. Standing pulse-rate	108	1	+.70	111	0	+.40
D. Pulse-rate increase immediately after exercise	20	0	—.72	21	—2	—1.10
E. Return of pulse-rate to standing normal after exercise	60	3	+2.75	61	+2	+2.26
F. Systolic pressure standing compared with reclining	8	3	+3.00	7	+2	+2.75
Rating		9	+5.91		0	+3.80

A brief study of Charts I and II may suggest that they do not look quite right for curves of biological functions, but no attempt has been made in this paper to question the essential soundness of the Schneider tables. On the contrary, the whole effort was centered in assigning interpolated values most consistent with the values given. If in this attempt some poor guesses have been made it is still hoped that the need for more accurate scoring has been demonstrated, and that the nomographs offered, or some improvement on them, will be found useful.

The Relation Between Chest Girth and Vital Capacity

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ONE of the common measures taken in a physical examination is the chest girth at expiration and inspiration, from which the amount of chest expansion is calculated. It is interesting to know what relation these measures have to the functional size of the lungs, i.e., to the so-called vital capacity. Baldwin (1921) found an average correlation of 0.69 between vital capacity and chest girth (whether expiration or inspiration is not stated) for boys between the ages of 7 and 17 years. Jackson (1929) quotes a value of 0.351 for the correlation between vital capacity and chest expansion for men students at the University of Minnesota. The difference between these two correlations is too large to be accidental, and they give entirely different pictures of the relation. The data of the present paper indicates perhaps the most important factor in this difference and tends to corroborate Jackson's findings.

One hundred unselected cases afforded the data upon which the statistical results shown in tables 1 and 2 were based. These cases were all boys attending a private school in Honolulu, and all had some mixture of Hawaiian blood. Chest measurements were taken at the level of the nipples and the vital capacity records were the best value of two trials on a wet spirometer.

TABLE 1
Averages and Standard Deviations of the Measures

		Aver.	s
Vital capacity	liters	2.1	0.34
Expiration girth	ins.	32.4	2.71
Inspiration girth	ins.	34.54	2.83
Expansion	ins.	2.14	0.77
Age	yrs.	15.7	2.06

TABLE 2

Correlations	r
r_{12} vital capacity vs. expiration girth	.54
r_{13} vital capacity vs. age	.35
r_{23} expiration vs. age	.60
$r_{12.3}$	.452
Inspiration girth vs. vital capacity	.55
Expansion (absolute)	.16
Expansion (relative)*	—.14

* Expansion (relative) $= \frac{\text{Expansion}}{\text{Expiration girth}} \times 100.$

It is evident from these tables that none of the measures of chest expansion have a very high relation to vital capacity. The circumferences at expiration and inspiration are nearly equally correlated, and this correlation is not sufficiently great to indicate a close relation. Further, the partial correlation with age constant is only .452. This value agrees better with Jackson's than with that of Baldwin. Age, at least as related to growth, was fairly constant for the adults measured by Jackson, while Baldwin's data are based on boys in the developmental period and they have not been corrected for age.

If we consider the effect on chest girth of contraction of the pectoral muscles, and on the other hand, the effect of familiarity with the apparatus on performance on the wet spirometer these results are not surprising. The data do give, however, experimental evidence that there is little or no relation between chest girth or expansion and vital capacity in normal boys. Pertinent to this conclusion is the following quotation from Jackson; "It is therefore evident that ...even in men the chest expansion is of little value as an indication of vital capacity... It would therefore seem that undue emphasis is laid upon the size of the chest expansion in physical examinations and especially in life insurance examinations."

REFERENCES

Baldwin, Bird T. 1921. The physical growth of children from birth to maturity. Univ. of Iowa Sud. in Child Welfare, Vol. 1, No. 1. Pp. 411, (cf. pp. 120 and 126).

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The Physique of Women Students at Newcomb College of Tulane University. II. Vital Capacity

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Department of Biology

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Total group
Age groups
Vital Capacity of Continuous Attendants
Total group
Groups according to year of entrance to college
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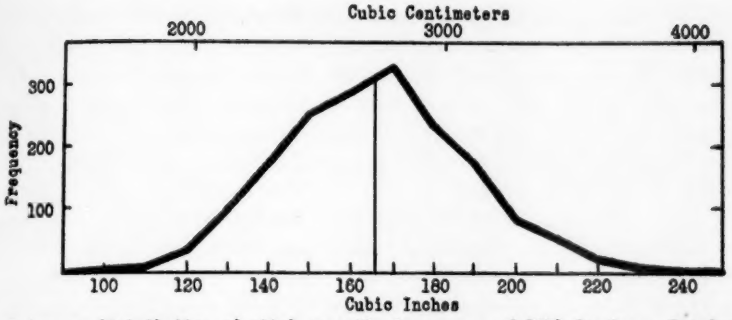
The Relation of Vital Capacity to Chest Expansion

INTRODUCTION

IN the first paper of this series (Gould, '30) the source of the material used and the general method of treatment are given in detail. Briefly, the Department of Physical Education at Newcomb College has taken a record of certain physical measurements in the fall and spring of each year on each student as long as she remained in college. The subjects are predominantly from Louisiana and contiguous states, the city of New Orleans furnishing over half of them. The records were first made in the fall of 1909, and are continuous to date. The data are being assembled in such a way as to give the statistical constants for these college women of the Gulf Coast region; to trace the changes in physique through the period of individual college attendance; and to disclose any changes or trends during the whole period covered by the records.

The present paper deals with the results of spirometric tests. In view of the several published studies on the lung capacity of college women, it seemed of particular interest to obtain standards for a region where, for several months of the year, physical activity is lowered as a result of high temperature and humidity.

The greater part of the data has been assembled and the constants have been determined by the junior author, and the operations checked by both of us. The original records of vital capacity were taken on a wet spirometer made by the Narragansett Machine Co. and graduated in cubic inches. We have not found any evidence of irregularity or unusual resistance in its operation. Subjects were tested standing, lightly and loosely clothed.



Frequency distribution of vital capacity in a group of 1771 freshmen. Based on one test of each person. Mean, 165.85 cu. in. (2717.6 c.c.); standard deviation, 23.20 cu. in. (380.2 c.c.).

FIG. 1

Vital Capacity of Freshmen

Figure 1 shows the frequency distribution of vital capacity in a group of 1771 freshman students. It is based on the second test of the freshman year, made in the spring. The total number is not so large as would be available if we used the first (fall) measurement, for many students fail to remain through the first year; but there were so many abnormally low scores on the first test as to suggest that unfamiliarity with the spirometer was partially responsible, and the results of the second test were thought more nearly to represent the actual vital capacity. The mean age, height and weight for the 1771 persons in this particular group have not been calculated, but for all entering freshmen at Newcomb College, of whom this group is a large part, the mean age is 18.04 years, the mean height 63.34 inches, and the mean weight 116.22 pounds.

The individual vital capacities are classified to the nearest ten cubic inches. The mean is 165.85±.37 cubic inches (2717.6±6.3 c.c.) and the median is very close to it, 165.72 cubic inches. The standard deviation is 23.20 cubic inches (380.2 c.c.). The coefficient of variability is 14 per cent.

Table 1 compares the mean vital capacity of these students with that of a few other groups of college women. A much fuller statement is given in Jackson's ('29) table 5, but we wish here merely to compare Newcomb freshmen with other large groups of college women of about the same period. It will be seen that the Newcomb students have the lowest mean vital capacity of any of these more or less contemporary groups. The difference can be partially, though probably not wholly, accounted for by the lesser stature of our subjects, since it is known that vital capacity and height are correlated to a certain extent. The weighted mean stature of the groups listed in table 1 from Wellesley, Vassar, Minnesota, Hollins and Stanford

is 1625.9 mm. (calculated from authors' data). The stature of Newcomb students at entrance averages 1608.8 mm., and allowing 3 mm. (.12 inch) for growth in height during the freshman winter (data from Gould, '30), the stature at the time the second test of vital capacity is made would be 1611.8. There is thus a difference of about 14 mm. in height for a difference of 184.7 c.c. in vital capacity, between Newcomb students and the combined other groups in table 1. It must be taken into consideration that the Newcomb freshmen are from one to two years younger than the entering students in some of the northern colleges cited, and that they increase in vital capacity (see below) during college attendance. We do not think, however, that the increase is due to age as much as it is to training.

TABLE 1

Vital Capacity of College Women, Comparative

Group	Number	Authority	Mean vital capacity (c.c.)
Wellesley freshmen	1150	Turner, '27	2990
Vassar freshmen 1916-20	1224	Newcomer, '21	2950
Minnesota University freshmen 1925-6	1015	Jackson, '29	2888.1
Hollins freshmen 1920-27	1017	Palmer, '29	2816.3
Stanford University	430	Pasmore and Weymouth, '24	2769
Total	4836	Weighted average	2902.3
Newcomb freshmen	1771	Present data	2717.6

Vital capacity of freshmen by age. Table 2 shows the relation of vital capacity to age, when the freshman students 16 to 19 years old are grouped to the nearest year. This is also based on the second freshman test. While the probable errors of the means are too large to allow confident comparison of any two successive ages, it is evident that there is a downward trend, or at least no gain, of vital capacity with more advanced age, in this group. As the same phenomenon has been observed in measurements of height and weight (Gould, '30), it is probable, as Jackson has suggested, that we are dealing with a selection of the physically sturdier for college entrance at younger ages.

TABLE 2

Vital Capacity of Freshmen by Age

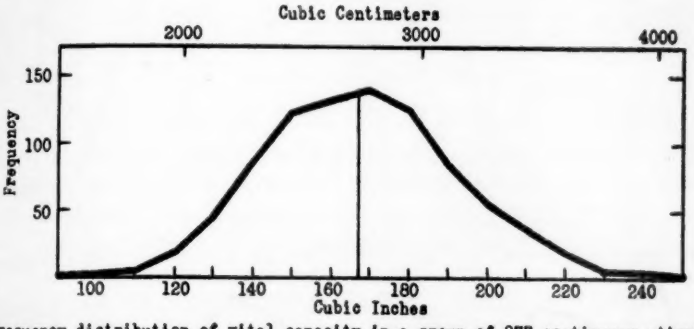
Age	Number	Mean vital capacity cu in.	Mean vital capacity c. c.
16	322	166.71± .83	2731.7±13.6
17	689	166.43± .59	2727.1± 9.7
18	473	164.74± .68	2699.4±11.1
19	160	164.25±1.23	2691.4±20.2

Vital Capacity of Continuous Attendants

We have selected for particular study a group of students who attended college for the full course of four years and who have not missed any of the physical examinations. For each person in this group we could average together the eight records of vital capacity,

and so arrive at a figure which would be much more dependable than one based on a single examination. We could also use the material to study the changes in vital capacity during the years of college attendance.

Vital capacity of the continuous attendant group as a whole. For the distribution chart shown in figure 2, 877 persons were used. The eight records of each person were averaged together to give a mean vital capacity for that person. The 877 such means were then used to construct figure 2. The total mean vital capacity is 167.34 cubic



Frequency distribution of vital capacity in a group of 877 continuous attendants. Based on a series of 8 tests on each person. Mean, 167.34 cu. in. (2742 c.c.); standard deviation, 24.37 cu. in. (399.3 c.c.).

FIG. 2

inches (2742 c.c.), and the standard deviation 24.37 cubic inches (399.3 c.c.). The mean is higher than that based on the second freshman measurement alone, because, as will appear presently, there is a gain in vital capacity during college attendance. The distribution curve is smoother than in figure 1; fewer persons are involved but many more individual records (7016). We regard figure 2 as the more accurate picture for the typical Newcomb group.

Vital capacity by groups according to year of entrance. We had rather expected to find somewhat higher vital capacities among the students of more recent years. Certainly the college women in this section have participated in outdoor sports more extensively in the last few years, and wear less confining clothing than hitherto. The records, however, do not appear to show what was expected.

The 877 continuous attendants were separated into groups according to the year of entrance to college, and, just before this paper was submitted for publication, two additional groups,—those entering in 1925 and a majority of those entering in 1926,—were added to them. The mean vital capacity of each group, based on eight tests of each person, is given in table 3. A graph of these successive means is shown in figure 3. No general upward trend is seen to involve the whole time series. Beginning with the class entering in 1917 there is

TABLE 3

Mean Vital Capacity of Successive Classes of Continuous Attendants, Based on Eight Tests of Each Person

Years of attendance	Number	Mean vital capacity
1909-13	18	161.91
1910-14	23	176.87
1911-15	32	166.89
1912-16	35	169.62
1913-17	60	170.40
1914-18	40	165.89
1915-19	45	167.91
1916-20	61	169.13
1917-21	43	160.90
1918-22	52	164.89
1919-23	85	165.98
1920-24	74	169.70
1921-25	83	172.87
1922-26	66	166.55
1923-27	71	163.91
1924-28	89	169.53
1925-29	90	168.83
1926-30	51	163.97

a regular increase in lung capacity up to the group entering in 1921; and so far as we are able to judge, there are no consistent increases

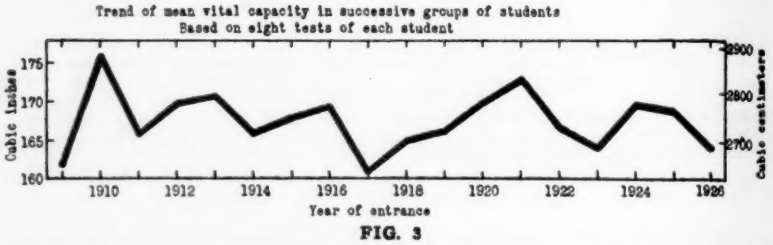


FIG. 3

in height and weight to account for it. These five years appear to be the only part of the entire series to show any definite trend.

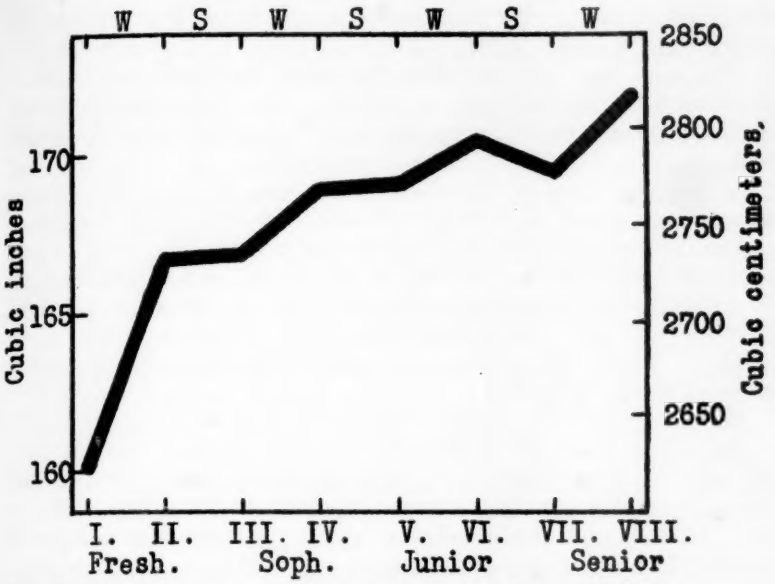
Change in vital capacity during college attendance. Using the same group of 877 continuous attendants, we have calculated the mean vital capacity, and the standard deviation in vital capacity, of the whole group for each of the eight half-yearly tests. The rather interesting results are shown in table 4 and figures 4 and 5.

TABLE 4

Mean Vital Capacity and Standard Deviation in Vital Capacity, in the Continuous Attendant Group, According to the Successive Half-Yearly Tests

Time	Mean		Standard Deviation	
	cu. in.	c.c.	cu. in.	c.c.
Freshman fall	160.07	2622.9	23.70	388.3
Freshman spring	166.62	2730.2	22.70	372.0
Sophomore fall	166.84	2733.8	23.65	387.5
Sophomore spring	168.84	2766.6	23.40	383.4
Junior fall	168.98	2768.9	24.75	405.6
Junior spring	170.42	2792.5	24.20	396.5
Senior fall	169.45	2776.6	24.90	408.0
Senior spring	171.80	2815.1	24.40	399.8

There is a total gain in mean vital capacity of 11.73 cubic inches (192.2 c.c.) during the entire period of attendance; but the most im-



Graph of the successive mean vital capacities of a group of 877 continuous attendants, based on the routine half-yearly tests. Average age at entrance, 17.6 years.

FIG. 4

portant consideration is the way in which the increments are added. By reference to figure 4 it will be noted that the gains in vital capacity take place almost entirely during the winter ("W") intervals, while in the summer ("S") intervals the vital capacity remains practically stationary, and in the junior-senior summer interval even decreases. To be perfectly certain of this seasonal difference we went over all the data a second time, making frequency distributions of the *change* in vital capacity for each of the seven intervals. The mean changes per interval, with their probable errors, are given in table 5. It is evident that the winter gains are statistically significant, and that the summer changes are for the most part insignificant. The means given in table 5 are substantially such as could be derived

TABLE 5

Mean Changes in Vital Capacity of 875 Continuous Attendants, by Intervals

Interval	Mean and probable error cu. in.
Freshman winter	+6.87±.28
Freshman-sophomore summer	+ .08±.26
Sophomore winter	+2.04±.25
Sophomore-junior summer	+ .21±.27
Junior winter	+1.34±.22
Junior-senior summer	—1.05±.23
Senior winter	+2.36±.23

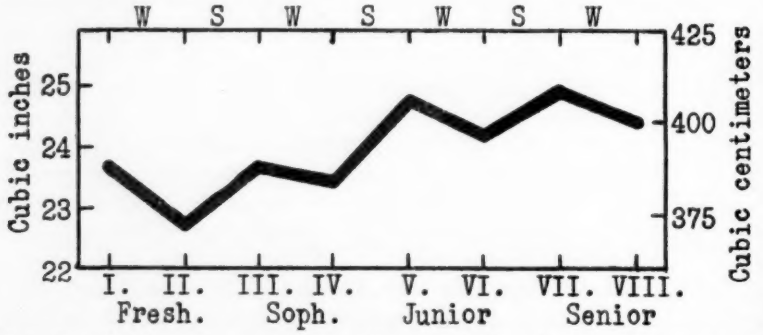
from table 4, though due to slight differences in the treatment of the data the check is not perfect.

We must conclude that there have been factors in the physical environment of the students during the winter that favor the gain in vital capacity—probably greater physical activity and more regular habits.

In the first paper of this series, cited above, studies of height and weight were made on a group of continuous attendants involving practically the same individuals which are used in the present work. Seasonal variations in attainment of height and seasonal fluctuations in weight, were encountered. Height increment is added more in winter than in summer; weight tends to go down in winter, up in summer. The present study, then, adds a third physical character showing seasonal variation.

The mean gain for the freshman winter, about six cubic inches, is probably misleading. Undoubtedly there is, actually, a large gain during this interval, but as we have previously stated, there are so many abnormally low figures among the records of the first freshman test as to suggest the inability of some unpracticed freshmen to register their full vital capacity on the spirometer.

Baldwin ('21) reported the results of four consecutive yearly spirometric tests on 80 Swarthmore college women. His figures also show a marked gain between the freshman and sophomore years, 9.21 cubic inches, and small gains of 1.65 and 1.15 cubic inches respectively for the following two one-year intervals. The total gain of 12 cubic inches is very close to our own finding.



Graph of the successive standard deviations in vital capacity in a group of 877 continuous attendants, based on the half-yearly tests.

FIG. 5

The standard deviations in vital capacity, as well as the means, for the eight successive tests, show seasonal variation. As shown in figure 5, there is a general rise in variability for the whole period,

but involved in this are summer increases and winter decreases. The general increase in variability for the whole period may be accounted for if we assume that some individuals are capable of increasing their vital capacity much more than others having the same physical training, just as some students advance mentally with more rapidity than others having the same instruction. At present we do not have any explanation of the seasonal shift in the standard deviation, which appears to be quite regular.

The Relation of Vital Capacity to Chest Expansion

Jackson has pointed out ('29 and previous papers) that "chest expansion is of little value as an indication of vital capacity." The result of Jackson's investigation which seemed quite remarkable was the much lower coefficient of correlation between vital capacity and chest expansion in college women (.12) than in college men (.35). It is commonly stated that "rib-breathing" is more characteristic of women, "abdominal" breathing more characteristic of men. If women do use the intercostal and neck muscles more, and the diaphragm less, than men, the correlation of vital capacity with chest expansion ought to be higher in women, rather than lower as Jackson finds. The idea of the different types of breathing in the two sexes arose perhaps more as a deduction of what must be true than as a result of statistical analysis. Formerly, of course, the wearing of clothing which restricted the movement of the abdominal muscles and diaphragm of women was general. The question arises whether there has been a demonstrable change in the type of breathing since the beginning of the corsetless era. We thought our material might throw some light on this, since chest circumferences at full inspiration and at full expiration, taken twice a year, are included on the record cards at Newcomb.

By adding some of the records most recently completed we were able to bring our "continuous attendant" group up to 1000 individuals. This was then divided into two equal groups of 500 each, the first including students from the class of 1909-13 partly through 1920-24, and the second from that point to and partly through 1926-30. The division is an attempt to separate the subjects, very roughly, into a corsetted and a corsetless group. The coefficients of correlation between vital capacity and chest expansion were calculated for each group separately. The vital capacity and chest expansion used for each individual, is actually an average of eight measurements on that person. We recognize that the measurement of chest expansion is subject to considerable inaccuracy, but by averaging eight records any single gross error would be greatly reduced.

The constants obtained for the two groups are given in table 6.*

* The method of grouping vital capacities for the correlation tables has made the mean vital capacities given in table 6 about one cubic inch lower than would be derived from table 3.

TABLE 6

Statistical Constants for an Earlier and a Later Group of Continuous Attendants, as Regards Vital Capacity and Chest Expansion. Based on Eight Tests of Each Person

Classes	1909-13 to 1920-24	1920-24 to 1926-30
Number	500	500
Mean vital capacity:		
cu. in.	164.72± .67	166.44± .68
c. c.	2699.1 ±11.	2727.3 ±11.
Standard deviation in vital capacity:		
cu. in.	22.44± .47	22.80± .48
c. c.	367.7 ± 7.7	373.6 ± 7.9
Mean chest expansion:		
In.	3.14± .02	3.70± .02
Mm.	79.7 ± .51	94.0 ± .51
Standard deviation in chest expansion:		
In.	.62± .01	.62± .01
Mm.	15.7 ± .25	15.7 ± .25
Coefficient of correlation between vital capacity and chest expansion	.50± .02	.33± .03

The coefficient of correlation for the earlier group is .50 and for the later one .33. The difference is significant, and we think it indicates more of the "abdominal" type of breathing in the students of the last few years.

The coefficient of correlation for our second group (1920-24 to 1926-30) is much higher than that given by Jackson for Minnesota female students of about the same period (1925-6); it is approximately the same as given for the male students of that university The mean chest expansions found by us are relatively high, con sidering that the mean vital capacity is rather low.

SUMMARY

Freshman women at Newcomb College have a relatively low mean vital capacity, in comparison with other similar and contemporary groups. The difference probably cannot be entirely accounted for by their lesser age and stature.

The older groups of freshman students have slightly lower vital capacity than the younger groups.

A group of "continuous attendants" (four-year students) have been studied separately. First the eight tests of each person have been averaged, and the constants for the entire group determined. Second, the entire group has been broken up into subgroups according to the years when they attended college. No definite trend in vital capacity has been shown, except for a limited period involving five consecutive groups. Third, all the first freshman tests, second tests, and so on, have been separately averaged to show the trend in vital capacity during the four years of college. There is a definite rise in vital capacity during the period of college life, but an intermittent one, the

increases taking place almost entirely in the winter. The variability in vital capacity also rises from the freshman to the senior year, and this rise is also intermittent, with the increases during the summers and subsequent drops during the winters.

The coefficient of correlation between vital capacity and chest expansion is found to have been higher during the earlier years of our records than recently. This is interpreted as showing a certain amount of change in the type of respiratory movement.

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A Study of the Incidence, Distribution and Treatment of Ringworm in Men Students at The University of Cincinnati*

L. B. Chenoweth, M.D. and Elmer Werner, M.D.

JUDGING from our experience ringworm is on the increase. The following table illustrates the gradual growth and spread of the disease, compared with the undergraduate male population of the University for the years in question.

TABLE I

Year	Maximum Undergraduate Male Population	Number of New Cases of Ringworm Discovered	Number per Thousand Known to Have Ringworm*
1922	1326	14	10.6
1923	1364	5	3.8
1924	1564	7	4.5
1925	1707	9	5.3
1926	1866	39	21.9
1927	1992	53	26.6
1928	2147	43	20.0
1929	2239	96	42.8
Jan. 1 to Mar. 1, 1930		20	

* Graphically illustrated in Chart I.

Ringworm shows a marked seasonal preference, especially ringworm of the toes. We have tabulated the time of year when students have come to us with the disease (Table II, Columns 1 & 2), or the time when we first discovered it. We have given the total number of office calls made by men students in the year 1929 for all conditions

TABLE II

Month in which new cases were discovered (from 1922 to 1929 inclus.)	Number of such cases	Total number of calls made to health service in year 1929 (a typical year).	Number of cases per 100 calls in a typical year*	Remarks
January	11	351	3+	Most of the cases in Jan., Feb., and Mar., 1929, were influenza and acute respiratory infections.
February	7	281	3+	
March	25	310	8+	
April	14	240	6—	
May	19	164	12—	Mostly summer session students
June	29	91	32+	
July	27	159	17—	
August	4	25	16	Very few students on campus. Small summer session.
September	41	705	6—	A large number of routine physical examinations performed at this time.
October	51	961	5+	
November	27	824	3+	
December	4	732	½—	

* Graphically illustrated in Chart II.

*Read before the joint meeting of the Student Health and Physical Education sections of the Ohio College Association, Columbus, Ohio, April 4, 1930.

by way of comparison (Column 3). We feel that some comparison is necessary to get the true picture, because even though illness in general is more prevalent in the winter months, yet we have noticed that ringworm is relatively more prevalent in the summer. This coincides with all observation on the subject.

In 257 cases the location of the lesions on the body were as follows:

TABLE III

Location	No. of Cases	Per cent of the Total
Generalized	2	.78
Scalp only	1	.39
Face only	3	1.17
Neck only	1	.39
Trunk only	8	3.11
Axilla only	1	.39
Arms only	3	1.17
Hands only	4	1.56
Crotch only	53	20.62
Legs only	2	.78
Feet only	148	57.59
Trunk and feet	1	.39
Trunk, Crotch and Feet	1	.39
External auditory meatus and crotch	1	.39
Face, Crotch and Feet	1	.39
Axilla, Hands and Feet	1	.39
Axilla, Crotch and Feet	2	.78
Axilla, Hands, Crotch and Feet	1	.39
Arms and Legs	1	.39
Hands and Feet	8	3.11
Crotch and Feet	14	5.45
Total	257	100.

If we summarize the cases in Table III we have the following commoner distribution in the order of their frequency.

TABLE IV

Location	Per cent of 257 Cases of Ringworm
Feet	68.87
Crotch	28.40
Hands	5.45
Trunk	4.66

Ringworm of the feet and groin then make up the great bulk of our cases in the age group with which we have to deal. The location seems to be very important in the prevention and treatment of the disease. It has been our experience that ringworm of the crotch is very easy to clear up while ringworm of the feet, in the majority of cases, is almost incurable. To find out the efficiency of the various treatments used we have written 287 letters to alumni and students whom we know have or have had the disease. The number of replies we receivd up to the first of April, 1930, was 115. A summary of the replies received will be found in table V.

TABLE V

	Ringworm occuring principally in:					
	Crural Region	Feet and Hands	Generalized or Body	Arms and Legs	Axillary	Face and External Auditory Meatus
Number who think they are cured.....	20	35	5	2	3	1
Number who think the condition has improved	3	44		1	1	
Number who think they are improved but have occasional acute exaccerbations ..		20				
Number who have noticed no change in condition		9				1*

* External auditory meatus.

No one has reported that the lesions have become worse. About two-thirds of the letters received indicate that ours was the only treatment followed. The rest have consulted their family physicians or specialists. Some claim to have successfully treated their own cases and credit a number of remedies with a cure or improvement.

Our own cases have been treated by several physicians in our department, each man using his own treatment. The remedies used were: Wilkinson's ointment (this relieves itching of the toes but so far as we know has cleared up but very few cases); salicylic acid and sulphur ointment (only a few cases have cleared up after using this); Kerolysin (Upjohn) (all cases of ringworm of the feet seem to be benefited by its use, but very few cleared up entirely with this remedy alone); Tincture of iodine (a number of cases in the crotch have been cleared up with this remedy alone; however, it has very little if any effect upon ringworm of the toes); Ammoniated mercury ointment (has worked well in Tinea cruris but nowhere else); Salicylic acid, sulphur and tar ointment (improvement but few cures); Mercurochrome 220 (seems to be useful only in the very early stages of the disease); water solutions of mercury bichloride (seem to be useful only when secondary infection is present—does not clear up the ringworm at all); thymol iodide (useful if there is marked cracking of the webs of the toes, but no cures with its use); Burrow's solution (practically no value); Whitfield's ointment—this is too weak as now prepared (we have had to double the amount of salicylic acid and benzoic acid given by Whitfield to get any results at all; it is, however, a very useful remedy and can be credited with some cures but it becomes very irritating when large proportions of salicylic and benzoic acids are used); saturated alcoholic solution of Gentian Violet (this relieves itching at once and may be credited with a few cures in ringworm of the feet and it works very well in ringworm of the groin); Air-cooled Ultra-Violet light (this has been very helpful especially when exposure has been long enough to pro-

duce marked erythemia with subsequent desquamation and several cures have followed its use). The following prescriptions have been used with fair success: *Thymol 2.0, Benzoic Acid 6.0, Salicylic Acid 12.0, Lanolin (Hydrous) and Petrolatum *aa* Q.S. ad 100.0; Tincture of Iodine 20 per cent in Spirits of Camphor used in A.M. in conjunction with above ointment which is used at night; Chrysarobin 10 to 20 per cent in Lanolin or petrolatum; Gentian Violet 5 per cent in alcohol (color objectionable). Other substances used are Potassium permanganate, aluminum acetate, silver nitrate, picric acid, resorcin, mercurochrome, Eucalyptus, Cloves, Cinnamon.

X-ray proved by far the most efficacious treatment but was expensive. More permanent cures in our series have resulted from its use than from any other therapeutic procedure and yet it has been used only as a last resort because of the expense involved. There are a few cases, however, which it has failed to benefit.

As far as the literature on this subject is concerned, several very instructive papers have appeared which should be of interest to those treating ringworm.

W. B. Wolfe (U. S. Naval Medical Bulletin, Vol. 22, 1925, p. 562) gives an excellent summary of the history of the diseases caused by the parasitic mould fungi.

Hazen has given an excellent general description of the disease (Eczematoid Ringworm, Journal American Medical Association, Oct. 11, 1924, Vol. 83, p. 1123) together with a long bibliography.

Butler, Houghton, and Cooper (U.S. Naval Medical Bulletin, Vol. XXI, p. 615, 1924) have given us a very excellent study of the mycoses of the hands and feet, together with valuable references.

Feldman and Ochs (Potassium Permanganate as a curative agent in Dermatologic Diseases, Archive of Dermatology and Syphilology 1922) recommend potassium permanganate in the treatment of ringworm in the strength of 1:1000, 1:2000 and 1:5000. (This treatment had not occurred to us until we reviewed the literature, too late to give it a trial.)

Albert Strickler (The vaccine treatment of ringworm of the scalp. Journal American Medical Association, 1915, Vol. LXV, p. 224) has used with success a vaccine prepared from causes of ringworm of the scalp and hair, a type very rarely seen in the adolescent period. This should be extended to the apparently incurable cases of ringworm of the feet.

Engeman and McGarry report "Two cases of Trichophytosis Barbae cured by the use of Strickler's Ringworm Vaccine." (Journal American Medical Association, Feb. 17, 1917, Vol. LXVIII, No. 7).

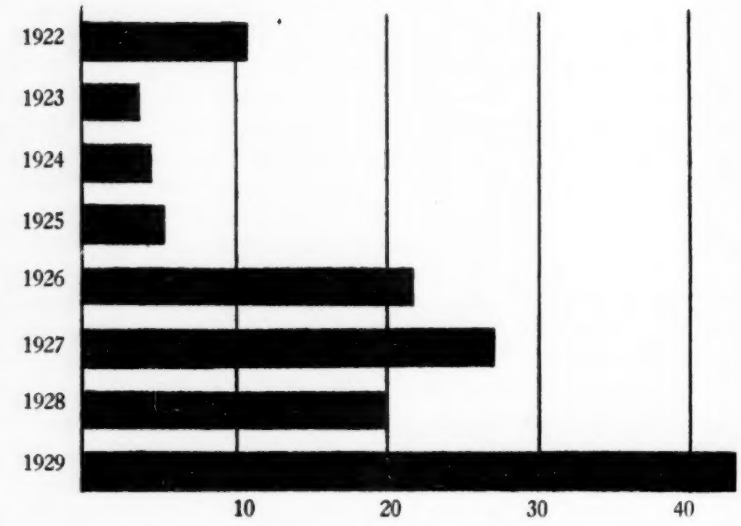
The lessons we have learned by our experience with ringworm and what we have gathered from reading the literature leads us to the following conclusions:

1. That ringworm is a group of diseases rather than a single condition, hence we notice that some cases are easy to cure while others may be classed, at present, as practically incurable. Some of the cases of our series were given expert treatment by competent skin specialists, and every known therapeutic procedure had been tried without success.

2. That the great majority of cases occurred on the feet or in the crotch,

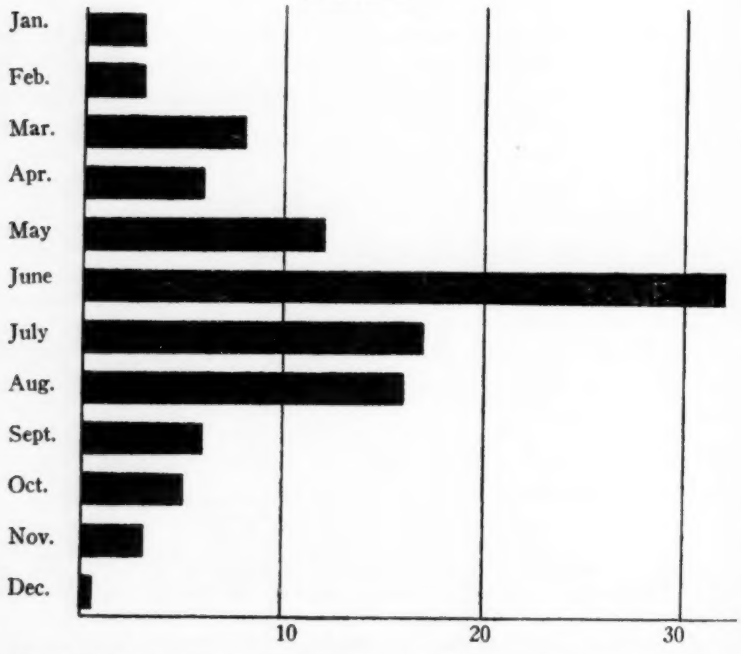
* Dr. Fred Wise—N.Y. State Journal of Medicine, Dec. 1, 1929.

CHART I



Number of cases of Ringworm per Thousand Male Students

CHART II



Number of new cases of Ringworm per 100 dispensary calls in 1929

and that these two conditions seem to be quite different. Tinea cruris is very easy to clear up while ringworm of the feet is extremely chronic and inclined to acute exaccerbations.

3. That ringworm of the scalp or beard is extremely rare in college students, however common the former may be in young children, or the latter in more mature adults.

4. That the threads and spores of the fungus live in the epidermis and not in the deeper skin, hence if desquamation can be induced, and the skin be kept dry at the same time the best results can be obtained. If ultra-violet light be used the dose must be enough to induce a marked erythema and desquamation. This is best accomplished by first painting the lesions with Mercurochrome 220 and then irradiating them. This latter procedure is not necessary in the great majority of cases however.

5. That ringworm of the feet is more apt to start between the fourth and fifth toes. Any survey can be quickly made by starting the inspection at this point. If time is limited the great majority of cases can be picked up by looking in this place only. Inspection should be made in physical education classes and those affected should be excluded from the gymnasium until the condition has cleared up.

6. That our figures do not include all of the cases. Hundreds of our students are treating themselves with widely advertised remedies, usually with poor success.

7. That prevention consists in the following: (a) absolute cleanliness of person and clothing. Each student should have two gymnasium costumes each one of which should be washed and boiled on alternate weeks. We realize that the boiling of jock straps ruins them, hence they should be made of material similar to the "Tetra" bandage or "Ace" bandage when the more they are boiled the more efficient they become. The ordinary jock strap is the most unhygienic piece of equipment there is. (b) Under no circumstance should anyone wear clothing previously worn by another without first having that clothing sterilized. The best way to sterilize the clothing is with steam under pressure; this should not be impossible in modern gymnasia where sterilizing equipment should be installed. (c) In using the shower and locker rooms the bare foot should never touch the floor. Rubber sandals are now available which cost less than two dollars. (d) Every case of ringworm should be excluded from the gymnasium and vigorously treated until cured. (e) We believe that there is a prophylactic and recommend that all students using a gymnasium should paint the webs of the toes with mercurochrome and keep them red. We have noticed that mercurochrome in the early stages of ringworm seems very efficacious. It should prove to be a good prophylactic.

Relative Influence of Diathermy and Other Physical Therapy Measures on Stiffened Joints

By Simon Benson

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INTRODUCTION

ONE might trace the beginning of physical therapy back "to that period of man's existence when" according to Dr. John Hilton "it (rest) was the sole curative means of which he could avail himself"; but physical therapy may, without much difficulty, be traced much further back—chronologically as well as genealogically.

The application of heat and cold, thermotherapy, as well as that of mechanical friction, massage, constitute no insignificant part of physical therapy; and the application of these measures are of daily occurrence—even among many lower animals. Who has not observed, for example, our domesticated friend, the dog, enjoy his daily "massage" by either licking or lapping himself or another of his fellow beings. Especially is it true that such animals will intensively lick any wound or aching part of the body. Apparently such mechanical stimulation or irritation gives relief,—lessens the discomfort by reducing the pain.

Man and animals alike shun pain or anything that causes pain; they greedily grasp for anything and everything which tends to reduce and remove pain. It seems reasonable, then, to assume that this licking and lapping by the animals produces a sensation of pleasure and comfort by lessening and possibly, in some cases, totally eliminating the pain. If otherwise, why would animals resort to it so frequently? Here, then, is probably the true beginning of the modern therapeutic measure known as massage.

Thermotherapy, the application of heat and cold,—where and how did it originate? Warmth, no doubt, was first enjoyed by the animals basking in the sunlight, but the application of cold was probably not put in the "Medical Dictionary" as an anodyne and tonic until a much later date. Not until that day, perhaps, when one of our prehistoric ancestors—fleeing from an enemy or wild animal —stumbled perspiring and exhausted into the cool mire of a swamp. The effect was unexpected and startling—but pleasing. The cool moisture produced a most comforting sensation: the pain in his overheated brow seemed to cease, and a general systematic stimulation

was experienced which gave him additional strength and vigor to escape his enemy. From that time on, applications of cold have been recognized and used—as well as abused—as a physical therapy agent.

No doubt, it is from some such beginning as those mentioned that our numerous agencies of healing, now practiced under the name of physical therapy, have been slowly but persistently developed. This development has been irregular, confused and erratic, to say the least; and treatments have often been applied in unscientific, unsystematic, and even crude manners, with highly injurious results. Specific curative measures have appeared on the physical therapy horizon like shooting stars—and have periodically been proclaimed the most effective of all times—only sooner or later to lose their brightness in the sparkling luster of some newer and still more effective remedy.

The battle has thus surged back and forth between the various camps of belligerents: some defending these "newer and better" remedies, while others have tenaciously clung to the "old reliable cures." Bombs of claims and counter-claims, of charges and counter-charges have been thrown from—and into—the various camps without reflection upon either cause or effect.

It is over such a controversial road that physical therapy, as we know it today, has been evolving. To be sure, physical therapy as we know it today is not, by any means, entirely liberated or rescued from the chaotic conditions of the past. We have with us, for example, the more or less friendly camps of hydro-, thermo-, mechano-, electro-, and radiant-therapy with their modern improved agencies and apparatus of application. Not only does one find considerable difference of opinion between the different camps but also among adherents of one and the same camp; differences which may concern not only WHAT to apply, but also WHEN and HOW it should be applied.

Electro-therapy, at least in some of its phases, is the latest of the curative mediums to arrive; and it, in all its various forms of application, has created a greater furore than any of the rest. From its blazing path in the physical therapy sky, it has thrown off several radiant satellites—the most dazzling of which is diathermy.

According to some of its strongest and most enthusiastic promoters, the manner in which diathermy is applied, as well as the effects to be derived from its use, are many and varied. A considerable difference of opinion also seems to exist in regard to the physiological channels through which such effects are made possible; thus indicating that, as yet, this curative measure has not come to be considered as a fixed star. The literature, then, leaves one much surprised by the appalling lack of consistency among the writers.

In general, one feels compelled to sympathize with Brown, Alt, and Levine who state that "In spite of the fact that this type of

current (high frequency) has been used in the treatment of disease for more than thirty years, there are relatively few investigations of clinical nature reported in the literature.... The literature abounds with reports of improvements, and even cures, of various conditions following the use of diathermy. One is impressed with the general optimism that prevails,"—but they continue—"one can not overlook the scarcity of reports of experimental work directed to establish a scientific basis for this impression."

Review of Literature

No extensive review of the literature is necessary to convince one that there has been, and still is, a woeful lack of scientific, quantitative data regarding the definite physiological effects of most of the physical therapy treatments. Reports of the effects of treatments upon a quantitative scale are rare indeed; most writers are seemingly wholly satisfied with inductions based upon the non-quantitative observations of a few isolated cases. Such generalizing is not only dangerous in itself but it becomes doubly so when it originates from individuals whose conception of the science of physics is somewhat rusty—a short-coming from which many of our present day writers seem to suffer. The J.A.M.A. comments on this phase in an editorial, Jan. 15, 1927. The editorial which is headed "Physical Therapy and Pseudophysics," draws the following conclusion: "This wanton display of pathetic ignorance arises, no doubt, from a desire to make physical science conform to preconceived theories as to the biological effect of physical energies."

In order to emphasize further the chaotic state in which physical therapy exists today,—to show the marked inconsistency which prevails among the writers and "authorities" on the subject,—we submit the following collection of extracts gathered from various authors:

"Diathermy is undoubtedly the most popular form of high frequency in use, and I do not wonder at this when I see some of the astonishing things accomplished by it.... The general action of diathermy is that of a mild, medium or powerful heat *definitely localized*[1] and produced within the body itself.... There is a softening effect of heat upon fibrosis and upon exudates, in fact the well known liquifying action of heat. Wherever located, adhesions are treated under the general proposition of softening them by the action of diathermy." (Eberhart). This claim of softening the tissues by diathermy does not agree with the results obtained in our experimental work, as will be shown later.

Let us turn to other writers: "If two equal sized electrodes are placed opposite, parallel to each other, the current density is greatest near the electrodes and for this reason heating occurs there first."

[1] All italics are ours.

(Ralph Bettman and Nathan N. Crohn). From this the inference may still be made that the heat is "definitely localized"; but it surely does not indicate that it is localized *within* the body itself.

Now listen to this: "The high frequency currents are the only agency by means of which we can heat the tissues through and through without excessive accumulation of action on the surface.... No organ or part of the body is so remote that it can not be reached by this mode of treatment, and the depth of the concentration can be determined with almost mathematical accuracy." (Neiswanger.)

In direct contradiction to the above, we quote the following from another source: "In a series of experiments on normal rabbits and dogs—they concluded that appreciable changes within the chest could be obtained only when such intense diathermy currents were employed that serious burns and sloughing of tissues would be liable to occur." (Charles L. Brown, Howard L. Alt and Samuel A. Levine.)

But still another writer has this to say: "...and the diathermic-heat superiority is explained: since the heat is generated WITHIN[1] the tissues the effect is incomparably greater than can be obtained by such means as hot baths or radiant heat which merely heat the surface of the body." (Turrell.)

Lonergan tried to determine the rise in temperature in a joint capsule by diathermy and reports as follows: "The highest rise obtained by inserting a thermo-couple in the joint capsule was 0.99°C. in the elbow joint of a dog by applying 600 milliamperes for 20 minutes." How does that compare with the two following statements: "By means of the diathermic current, the heart, the lungs, the kidneys, the ovaries, EVERY ORGAN OF THE BODY, or a limb throughout its whole length may be heated to any desired extent" (Turrell); and from Grover "By means of high frequency, we are now able to apply an internal poultice to the organ itself."

Diathermy and Pain

"Diathermy produces marked analgesic effects and relieves ALL KINDS of pain. Relief from diathermy is more lasting than from conductive or radiant heat." (Grover).

In another place we read this by Turrell: "This relief from pain (by diathermy) constitutes by far the most valuable property of diathermy." But he continues: "Occasionally a temporary increase in pain may be experienced during the administration of the current," but he concludes that this *increase* of pain is a good symptom for "the subsequent relief is generally very marked in these cases." If such a conclusion is of any value, then one should, of course, ALWAYS try to obtain such a pain-reaction during the administration of the current!

[1] All capitals are ours.

Duration of a Diathermy Treatment

"To restore a joint to normal motion we should use radiant heat followed by diathermy for THIRTY minutes, gentle massage and early motion" (Coulter). But Turrell thinks that: "Perhaps the best results are obtained by administering a diathermy current of moderate strength for about TEN minutes—."

Swelling After Diathermy

Granger thinks that much which has been written about the swelling of the tissues under diathermic electrodes has been much overstated. In fact, he suggests that parts which may be encased in plaster casts should be treated without removing the cast. That this does not coincide with the opinion of two other authors is evident by the following: "In giving treatments by diathermy it is important to see that no part of the body is constricted by tight clothing..Through stimulation of the circulation the tissues SWELL to such an extent that bandages unduly constrict the part." (Grover); and "Never in any circumstance administer a diathermy treatment to a limb incased in a rigid cast of splints as there is real danger of producing a condition even worse than a nerve injury—Ischemic paralysis." (Sampson).

Physical Effects of Diathermy

"The way this heat (from diathermy) is formed—by virtue of the resistance of the tissues themselves—in the very tissues we wish to have the heat, makes it certain that the heat is delivered exactly where we want it. The further fact that bone, callus and scar tissue offer a higher resistance insures their receiving more heat than the surrounding tissues, although the surrounding tissue can be heated to a high degree," (Sampson). On another page, however, this same author informs us that: "The amount of heat formed in the conductors or tissues varies as the square of the amperage," and that "Blood actually heats less than any other tissue from the passage of the current itself as it has less resistance than any of the other tissues." This author seems to be wholly ignorant of the fact that such a conclusion would be logical only in case the different tissues through which the current passes were arranged in "series" and not, as they apparently are, in "parallel."

"We have every reason to believe, judging from clinical experience, that by means of molecular or atomic massage, the increased internal body resistance is lowered materially," (Neiswanger). This author does not make clear just what he means by "internal body resistance" or what benefits may be derived by its being "lowered materially." Neither can we form any conception of a "molecular

or atomic massage"! However, such "preconceived theories," by another author, have carried the effects of electrical currents upon the body tissues to a still finer division: "It seems reasonable to suppose that this IONIC massage must have some such...stimulating ...effect." (Turrell). He steps unhesitatingly from the mysterious realm of molecular massage to one still more mysterious—that of IONIC massage! If one were to pay any serious attention to such speculative statements, such meaningless phrases, it would necessitate the discarding of whatever limited amount of knowledge and reason one may possess.

Diathermy, however, is not the only phase of physical therapy on which the literature fails to agree.

Light and Radiant Heat

"It is now generally admitted that incandescent rays penetrate the tissues to a depth of four to six inches....Light possesses many physical qualities which, when properly understood, readily give it first place among natural agencies for therapeutic application. The heat is produced WITHIN the body instead of being applied at the surface only." (Neiswanger).

"In the relief of pain, I think this form of treatment stands pre-eminent in the armament of the modern electro-therapy." (Goodman).

The physiological effects of different colored rays, "Red, green, yellow, violet, etc., all have different physiological effects. This can be proved clinically." (Neiswanger). But note the positive contradictory statement by another writer: "There is no basis for the belief that the color of the incandescent lamp (light) in any way affects the efficiency of the treatment." (Turrell).

Skinner, in his book on "Therapeutics of Dry Hot Air," claims differences between "the spheres of action of dry hot air, radiant heat, and hydrotherapy, and in securing satisfactory therapeutical results, the selection becomes a matter of importance; they are," he concludes, "by no means interchangeable." However, he fails to indicate any specific difference between any of them.

Hydrotherapy

"Whirlpool baths are said to stimulate the arterial circulation in a most powerful manner....relieve the pain and muscular spasm.... the tissues become more supple and movements can be made which previously were painful or impossible." (Baruch).

"The bath is useful as a precedent to massage or manipulation and is a good treatment for arthritis, tenosynovitis, etc., but not so good as diathermy." (Sampson).

"It (the whirlpool) is not well to use for arthritis or any nerve involvement, for in these cases the symptoms are aggravated by such

baths. It stimulates the circulation and prepares the part in a very short time for diathermy, massage or resistive movements." (Hinsdale). Why a whirlpool bath with its strong stimulating action on the circulation should be necessary as a preparation for diathermy is not made clear by this author.

Whirlpool, to be sure, flushes the skin with blood, but why such a flushing should be a desired PREPARATION for diathermy is far from evident. Of course, if the flushing could be limited to the area to be covered by the electrodes (thus giving better conductance to that area alone) the usefulness of such "preparing" would at once become apparent. As it is, however, the skin of the entire limb is affected—its resistance lowered—with the subsequent result that the diathermy current, when later applied, has a greater tendency to follow the path of lessened resistance along the surface than it had before this resistance was lowered; and the inevitable conclusion is that the current does not penetrate into the deeper tissues as much as would be the case had the surface resistance not been reduced. It would seem, therefore, that the application of whirlpool BEFORE diathermy actually tends to nullify the effect for which diathermy is *specifically* applied, namely, DEEP HEAT.

Such, then, were the conditions as we found them when we set out to ascertain, if possible, the most efficient treatments for athletic injuries. The literature, apparently did not help us in determining the issue; in fact, it left us more confused than ever. Because of this disagreement on matters both general and specific, plus the desire to put the problem on a quantitative and therefore scientific basis, the following studies were pursued.

EXPERIMENTAL METHODS

General Procedure: The investigations recorded in this report were all performed in the Training Division of the Athletic Department of the University of Chicago. The type of injuries treated are probably best described by the term "athletic injuries." Feeling that these are best understood by their common names, such as "Charley Horse," we have applied these names in several instances. Nothing worth-while would be gained by entering into long discussions aimed to clarify such much debated questions as "Just what is a Charley Horse?" Personally, we consider it a muscle bruise or contusion which may, or may not, involve the underlying bone. This is generally accompanied with internal bleeding causing coagulation and hardening of the area involved. Much difference of opinion also seems to exist as to "what is what" in a sprained ankle. We shall, however, merely call it a sprained ankle, and let others more versed in the subject settle the question of the exact pathology involved.

The patients, practically all members of the University Varsity squads, were young men in the best possible health, evidenced not only by their athletic activities but also by previous physical examinations performed by the team physician, Dr. C. O. Molander. This, we feel, is an important feature since it serves to eliminate the possibility of complications which might otherwise be traceable to previously existing pathological conditions.

All injuries were diagnosed by the team physician as soon as possible after the injury had occurred, and if he thought it necessary the patient was sent to the hospital for further diagnosis and X-ray. This, of course, helped materially in deciding what kind of treatments to apply.

Usually, no heat treatment was applied during the first twenty-four hours after the injury; but this time would, of course, vary with the type and severity of the injury. The motility of the joint affected by the injury was measured both immediately before and after each treatment. By a specially designed measuring device such measurements could be taken both rapidly and comparatively accurately. By repeating the measurements, they were generally found to check within one degree. The device is pictured opposite page 60, also its mode of application in measuring the flexion of a knee and ankle joint.

As far as technique is concerned, we can only say that the most common and accepted methods of today were employed. They were determined chiefly by the type of injury, i.e., the part of the body to be treated and the location of the injury, superficial or deep. Accordingly, we employed a great variety of combinations of "cuff and cuff," "plate and plate," as well as combinations of these two. We also tried a great variety of treatments; from extreme "sedative" to extreme "stimulative," as well as various combinations of these two.

The dosage in milliamperes was always determined by the individual tolerance, but often kept well below that limit. To prescribe a certain number of milliamperes per so many square inches of electrode applied is a beautiful theory, but we have become convinced that it has no place in practical work. Indeed, we have seen cases in which the same electrodes have been used for two different individuals in similar injuries—as in a sprained ankle—and the milliamperage applied and tolerated by one individual would be almost twice that of the other. Of course, there is a relation between the size of the electrodes applied and the current tolerated, but this varies so greatly that those who try to determine the dosage in this manner will soon throw up their hands in despair. It appears to be purely a case of individual tolerance of the patient and of the individual judgment of the operator.

Both whirlpool and hot air treatments were usually applied as hot

as the individual tolerance would permit: in the case of whirlpool, up to 112°F; in the case of hot air, up to 325°F. In the latter case the limb was always wrapped in towelling.

Radiant heat was likewise applied to skin tolerance which would be increased considerably if the skin were covered with some oil. The average time of application of these three treatments was: whirlpool, 15 minutes; hot air, 50 minutes; radiant heat, 25 minutes.

Special Terminology Used in the Case Studies

Although the terminology used in the following tables is largely self-explanatory, it is nevertheless thought best to define it more definitely so as to avoid misunderstandings and misinterpretation.

"Group-treatment" is a term used to signify collectively all the treatments given in immediate sequence, such as for example, diathermy, whirlpool and massage, i.e., these three treatments would be given in the order named immediately following each other. Any one case recorded may have one or several such group-treatments.

"Normal flexion" indicates the degree of flexion the joint would have under normal conditions. It was determined by measuring the joint of the other extremity. This was measured in order to obtain a fair indication of the extent of the existing subnormality in the injured member.

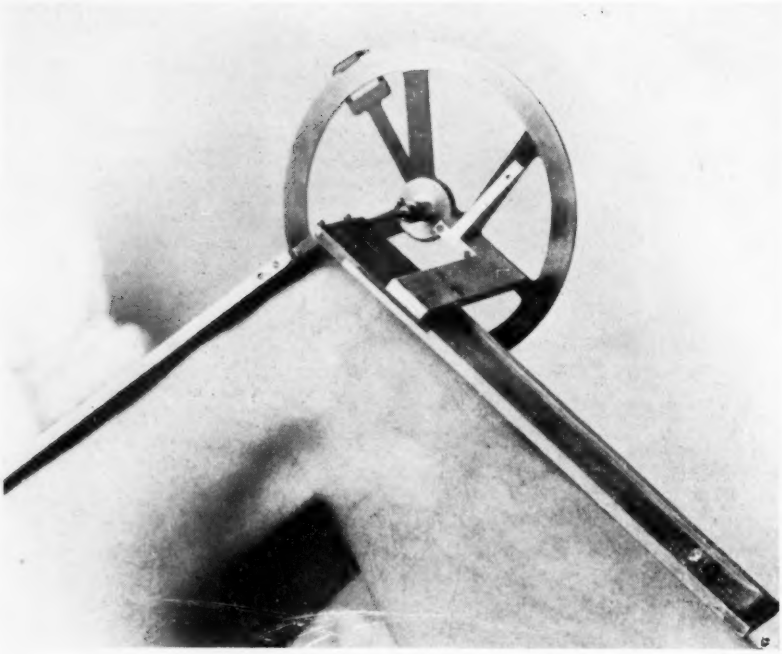
"Motility variation" shows the number of degrees the motility varied during one group-treatment. For example, in the flexion of an elbow, the variation in motility would be measured both during and after the group-treatment and compared with the degree of motility which existed before the treatments began. It is indicated thus: (74° to 106°),—which means that the reading before the treatment started was 74°, and that at the end of the group-treatment the reading was 106°.

It is important to remember that in figuring the influence of the individual treatments involved in a certain group treatment in per cent (%), this per cent is in relation to the total *motility variation* for that group treatment, because in some cases a loss occurs between two gains and is overcome by the latter. Such a loss does not influence the motility variation but nevertheless is calculated in relation to it. This makes the percentage column appear wrong, while in reality it is due to this "loss" coming in between two gains. See the second group-treatment of the first case. In cases like a sprained ankle, in which both the extension and flexion have been measured, the results of these two measurements have been added together, and this added variation is called the "combined motility variation."

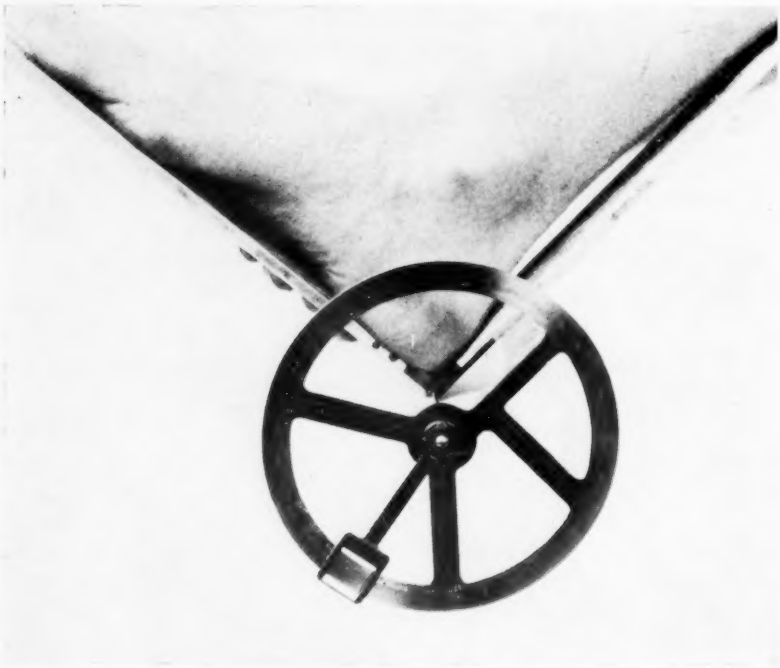
Under the heading "Variation" are listed the results of each individual treatment in a group treatment; and in the next column under "Variations Added" each variation is added to the preceding one, which then, in the final, gives the ultimate "loss" or "gain" of that group treatment. This, of course, may vary considerably from that of the "total motility variations" as will be clear upon examining one of the case reports.

THE MEASURING DEVICE

This measuring device was used to measure the motility immediately before and after each treatment.



The measuring device applied in measuring the flexion of a knee.



The measuring device applied in measuring the flexion of an ankle.

By motility we mean *active* motility, not *passive* movements. The patients were requested to "flex or extend" as far as they could, always, of course, under the same physical positions, lying, sitting, or standing. Measurements repeated almost always checked within one degree. In cases which involve more than one group treatment, there is a final summary of the combined effect of all the group treatments of that case.

Typical Case Reports

CASE NO. 1: STRAINED DELTOID

Illustrating effect of:
"Hot water, plus diathermy, plus massage, plus hot water" combination.

First Group Treatment

		Variation	Variations Added
Abduction of arm before treatment	50 degrees		
1. Abduction after diathermy.....	59 degrees	9 degrees	
2. Abduction after hot water.....	90 degrees	31 degrees	40 degrees

Of the total motility-variation (from 50° to 90°) of 40 degrees,
Diathermy as the 1st. treatment gained 9 degrees or 22½ per cent.
Hot water as the 2nd. treatment gained 31 degrees or 77½ per cent.
Thus leaving a final gain of 40 degrees or 100 per cent[1].

Second Group Treatment

		Variation	Variations Added
Abduction of arm before treatment.....	74 degrees		
1. Abduction after hot water.....	101 degrees	27 degrees	
2. Abduction after diathermy.....	89 degrees	−12 degrees	15 degrees
3. Abduction after massage.....	99 degrees	10 degrees	25 degrees
4. Abduction after hot water.....	106 degrees	7 degrees	32 degrees

Of the total motility-variation (from 74° to 106°) of 32 degrees,
Hot water as the 1st. treatment gained 27 degrees or 84 per cent.
Diathermy as the 2nd. treatment lost 12 degrees or 39 per cent.
Massage as the 3rd. treatment gained 10 degrees or 32 per cent.
Hot water as the 4th. treatment gained 7 degrees or 22 per cent.
Thus leaving a final gain of 32 degrees or 100 per cent.
Note: The loss from diathermy comes between and is overcome by two gains; hence the apparent inaccuracy in the per cent column.

CASE NO. 8: ACROMIO-CLAVICULAR SPRAIN

Illustrating effect of:
1—Hot air plus diathermy combination.
2—Pain reaction from diathermy.
3—Radiant heat plus diathermy combination.
Note the *time* applications in the third and fourth group treatments.

First Group Treatment

		Variation	Variations Added
Abduction of arm before treatment.....	65 degrees		
1. Abduction after hot air	103 degrees	38 degrees	
2. Abduction after diathermy.....	100 degrees	− 3 degrees	35 degrees

Complained that "movement was more painful after diathermy."
Of the total motility-variation (from 65° to 103°) of 38 degrees,
Hot air as the 1st. treatment gained 38 degrees or 100 per cent.
Diathermy as the 2nd. treatment lost 3 degrees or 8 per cent.
Thus leaving a final gain of 35 degrees or 92 per cent.

Second Group Treatment

		Variation	Variations Added
Abduction before treatment.....	66 degrees		
1. Abduction after hot air.....	76 degrees	10 degrees	
2. Abduction after diathermy.....	66 degrees	−10 degrees	0 degrees
3. Abduction after massage	66 degrees	0 degrees	0 degrees

Of the total motility-variation (from 66° to 76°) of 10 degrees,
Hot air as the 1st. treatment gained 10 degrees or 100 per cent.
Diathermy as the 2nd. treatment lost 10 degrees or 100 per cent.
Massage as the 3rd. treatment gained 0 degrees or 0 per cent.
Thus leaving a final gain of 0 degrees or 0 per cent.

[1] Each motility-variation is in itself considered as 100 per cent. See page 60.

Third Group Treatment

		Variation	Variations Added
Abduction before treatment.....	133 degrees		
1. Abduction after radiant heat (60′)[1]	170 degrees	37 degrees	
2. Abduction after diathermy (15′)..	161 degrees	− 9 degrees	28 degrees

Of the total motility-variation (from 133° to 170°) of 37 degrees,
Radiant heat as the 1st. treatment gained 37 degrees or 100 per cent.
Diathermy as the 2nd. treatment lost 9 degrees or 24 per cent.
Thus leaving a final gain of 28 degrees or 76 per cent.

Fourth Group Treatment

		Variation	Variations Added
Abduction before treatment.....	85 degrees		
1. Abduction after diathermy (60′)..	110 degrees	25 degrees	
2. Abduction after radiant heat (15′)	138 degrees	28 degrees	53 degrees

Of the total motility-variation (from 85° to 138°) of 53 degrees,
Diathermy as the 1st. treatment gained 25 degrees or 47 per cent.
Radiant heat as the 2nd. treatment gained 28 degrees or 53 per cent.
Thus leaving a final gain of 53 degrees or 100 per cent.

Note: The *time* application in the last two group treatments and the difference in results of the "2nd. treatment" of these cases.

CASE NO. 8 — SUMMARY

Group Treatments	Diathermy	Hot Air	Massage	Radiant Heat	Group Gain
I.....	− 3	38			35
II.....	−10	10	0		0
III.....	− 9			37	28
IV.....	25			28	53
Total Modality Gain..	3	48	0	65	

CASE NO. 9—SUMMARY
CHARLEY HORSE

Group Treatments	Dia-thermy	Whirl-pool	Hot Air	Mas-sage	Radiant Heat	Group Gain	Football Practice
I	-10_2	23_1				13	
II	0_1	12_2				12	
III	-1_1	16_2		6_3		21	
IV	-5_2	16_1				11	
V			3_1			3	
VI	-7_2	8_1				1	
VII	0_2		16_1			16	
VIII	0_2	11_1		8_3		19	
IX	-9_4	24_3		-6_2	0_1	9	
X		0_2	10_1			10	
XI		5_1				5	2
XII		4				4	
XIII		5				5	−10
Total Modality Gain .	−32	124	29	8	0		

Note: Sub-figures indicate order in which treatments were given.
Best combination was group III: Diathermy plus whirlpool plus massage.
Poorest combination was group VI: Whirlpool plus diathermy.

Knee-flexion:
1. At the beginning of treatments—51 degrees
2. At the end of treatments—130 degrees
3. Normal flexion in this case—130 degrees

CASE NO. 12. SPRAINED KNEE

Illustrating the fluctuations of flexibility during the diathermy treatment. It should be realized, however, that the flexibility shown here after, say, fifteen minutes, is not necessarily the true flexibility which would have been observed had the treatment been applied uninterruptedly for these fifteen minutes, because in this case the knee was flexed to the limit three times during the fifteen minute treatment, which, if anything, would tend to prevent rigidity.

		Variation	Variations Added
Normal Flexion	140 degrees		
Flexion before treatment.....	79 degrees		
1. Flexion after hot air	90 degrees	11 degrees	
2. Flexion after massage and passive movements	93 degrees	3 degrees	14 degrees
3. Flexion after diathermy (2′)[1]	90 degrees	− 3 degrees	11 degrees
Flexion after diathermy (5′)	90 degrees	0 degrees	11 degrees

[1]Time in minutes.

Flexion after diathermy (10′)	85 degrees	– 5 degrees	6 degrees
Flexion after diathermy (15′)	88 degrees	3 degrees	9 degrees
Flexion after diathermy (20′)	90 degrees	2 degrees	11 degrees
4. Flexion after whirlpool (8′)	100 degrees	10 degrees	21 degrees

Of the total motility-variation (from 79° to 100°) of 21 degrees,
Hot air as the 1st. treatment gained 11 degrees or 52 per cent.
Massage and passive movements as the 2nd. treatment gained 3 degrees or 14 per cent.
Diathermy as the 3rd. treatment lost 3 degrees or 14 per cent.
Whirlpool as the 4th. treatment gained 10 degrees or 48 per cent.
Thus leaving a total gain of 21 degrees or 100 per cent.

CASE NO. 17—SUMMARY
BRUISED KNEE

The summary of this case is submitted because of the interesting feature that it was the only case in which the patient, at times, experienced decided increase in stiffness from the whirlpool treatment, and, in general, relaxation from diathermy. The injury had produced an exceptionally large superficial extravasation of fluid—a hematoma. No synovitis present. The fluid was subsequently drawn off with a syringe and recovery was rapid.

Group Treatment	Dia-thermy	Whirl-pool	Hot Air	Massage and Passive Movements	Group Gain
I	–3	6	–8	17	12
II	–3	10			7
III	4	– 4			0
IV		–10	1		– 9
V	2	6			8
VI	3	12			15
VII	5	–14			– 9
Total Modality Gain	8	6	–7	17	

CASE NO. 18—SPRAINED ANKLE

Illustrating: Hot air plus diathermy effect.

		Variation	Variations Added
Normal flexion	100 degrees		
Flexion before treatment.....	86 degrees		
1. Flexion after Hot air	94 degrees	8 degrees	
2. Flexion after diathermy.....	95 degrees	1 degree	9 degrees

Of the total motility-variation (from 86° to 95°) of 9 degrees,
Hot air as the 1st. treatment gained 8 degrees or 89 per cent.
Diathermy as the 2nd. treatment gained 1 degree or 11 per cent.
Thus leaving a final gain of 9 degrees or 100 per cent.

		Variation	Variations Added
Normal Extension.....	136 degrees		
Extension before treatment	129 degrees		
1. Extension after hot air.....	133 degrees	4 degrees	
2. Extension after diathermy.....	132 degrees	– 1 degree	3 degrees

Of the total motility-variation (from 129° to 133°) of 4 degrees,
Hot air as the 1st. treatment gained 4 degrees or 100 per cent.
Diathermy as the 2nd. treatment lost 1 degree or 25 per cent.
Thus leaving a final gain of 3 degrees or 75 per cent.

Of a combined motility-variation of 13 degrees:
Hot air as the 1st. treatment gained 12 degrees or 92 per cent.
Diathermy as the 2nd. treatment gained (1 degree minus 1 degree) or 0 per cent.
Thus leaving a combined final gain of 12 degrees or 92 per cent.

CASE NO. 19—SPRAINED ANKLE

Illustrating: effect of diathermy alone.

		Variation	Variations Added
Normal Flexion.....	102 degrees		
Flexion before treatment.....	92 degrees		
1. Flexion after diathermy (5′)[1]	98 degrees	6 degrees	
2. Flexion after diathermy (15′)[1]	97 degrees	– 1 degree	5 degrees
3. Flexion after diathermy (20′)	97 degrees	0 degrees	5 degrees
4. Flexion after diathermy (30′)	97 degrees	0 degrees	5 degrees
Normal Extension.....	139 degrees		
Extension before treatment.....	122 degrees		
1. Extension after diathermy (5′)	128 degrees	6 degrees	
2. Extension after diathermy (15′)	125 degrees	– 3 degrees	3 degrees
3. Extension after diathermy (20′)	125 degrees	0 degrees	3 degrees
4. Extension after diathermy (30′)	125 degrees	0 degrees	3 degrees

Of a combined motility-variation of 12 degrees:

Diathermy as the 1st. treatment gained 12 degrees during the first five minutes of application but lost 4 degrees or 33 per cent on continued application. This would indicate that wherever diathermy does produce relaxation, it does so during the first few minutes of application, after which rigidity begins to set in.

[1]Time in minutes.

CASE NO. 22—SUMMARY
SPRAINED ANKLE

Group Treatment	Dia-thermy	Whirl-pool	Hot Air	Group Gain
I	− 4		10	6
II	− 2	14		12
III	− 7	5		− 2
Total Modality Gain	−13	19	10	

FINDINGS

Since we are interested chiefly in the effect of diathermy as compared with that of whirlpool and hot air, we shall discuss only those factors which relate to these particular applications. Although such treatments as radiant or infra-red heat have been applied, they have seldom been resorted to in cases recorded here. The radiant heat has been applied chiefly in the more superficial injuries. In the few cases in which its actions have been recorded here, the results may be obtained by looking up the individual case.

Massage, on the other hand, has been applied almost constantly after the various heat treatments. Its effect on the motility factor is, as a rule, very small when applied in this manner, i. e., *after* heat treatments. In those cases which we have measured, the results indicate that it should be applied briefly and gently and should be followed by passive movements. In general, we have found that in such cases as here treated, the application of massage and passive as well as active exercise is very beneficial—*provided* they are *not overdone*. The slightest excessive application of either seems to produce a decided negative influence on the motility. Of course, there may be cases in which a more vigorous application may be desirable, as when the ultimate recovery is of greater primary importance than is an immediate increase in motility. For example, a "Charley Horse" involving considerable "idiomuscular" contractions would, in order to loosen up this contraction and the accompanying congestion, require a comparatively vigorous application of massage. Such a treatment quite often proves to be painful and irritating with a temporary decrease in motility, but the subsequent effect may prove favorable in shortening the time of recovery by hastening the removal of the congested material.

Our results from diathermy, whirlpool and hot air may be summarized as follows:

Applied as the FIRST treatment:

DIATHERMY—In fourteen different cases of injuries it was applied twenty-four times. In twelve of those treatments it *gained* 91° at the average rate of 7.6° per treatment; in ten of the treatments it lost 55° at the rate of 5.5° per treatment; in two treatments there was no change. All in all, it gained (91°—55°)=36° in twenty-four treatments at the rate of 1.5° per treatment.

WHIRLPOOL—In twelve different cases of injuries it was applied thirty times. In twenty-six of these treatments it gained 287° at the average rate of 11.1° per treatment; in two of the treatments it lost 18° at the rate of 9° per treatment; in two cases there was no change. All in all it gained (287°—18°)=269° in thirty treatments at the rate of 8.4° per treatment.

HOT AIR—In thirteen different cases of injuries it was applied eighteen times. In sixteen of these treatments it gained 285° at the rate of 16.8° per treatment. In one treatment it lost 20° All in all it gained (285°—20°)= 265° in eighteen treatments at the rate of 14.2° per treatment.

Applied as the SECOND treatment:

DIATHERMY (with whirlpool as the FIRST treatment)—In ten different cases of injuries it was applied twenty-four times. In seven of these treatments it gained 25° at the average rate of 3.6° per treatment. In fourteen of these it lost 101° at the rate of 7.3° per treatment; in three cases there was no change. All in all, it gained (101°—25°)=76° in twenty-four treatments at the rate of 3° per treatment.

DIATHERMY (with hot air as the FIRST treatment)—In ten different cases of injuries it was applied twelve times. In one of these treatments it gained 5°; in eleven it lost 61° at the average rate of 5.5° per treatment. All in all, it lost (61°—5.5°)=55.5° in twelve treatments at the rate of 4.5° per treatment.

WHIRLPOOL (with diathermy as the FIRST treatment)—In ten different cases of injuries it was applied eighteen times. In seventeen of these treatments it gained 186° at the average rate of 10.9° per treatment; in one treatment there was no change. All in all, it gained (186°—0°)=186° in eighteen treatments at the rate of 10.3° per treatment.

HOT AIR (with diathermy as the FIRST treatment)—In two different cases of injuries it was applied twice. All in all, it gained (25°—0°)=25° at the rate of 12.5° per treatment.

Regardless of Sequence:

DIATHERMY—In twenty-three different cases of injuries, it was applied sixty times. In twenty of these treatments it gained 121° at the average rate of 6.0° per treatment; in thirty-four of the treatments it lost 211° at the rate of 6.2° per treatment; in six treatments there was no change. All in all, it lost (211°—121°)=90° in sixty treatments at the rate of 1.5° per treatment.

WHIRLPOOL—In sixteen different cases of injuries, it was applied forty-eight times. In forty-three of these treatments it gained 473° at the average rate of 11° per treatment; in two of the treatments it lost 18° at the rate of 9° per treatment; in three treatments there was no change. All in all, it gained (473°—20°)=453° in forty-eight treatments at the rate of 9.4° per treatment.

HOT AIR—In fourteen different cases of injuries, it was applied twenty times. In nineteen of these treatments it gained 310° at the average rate of 15.8° per treatment; in one of the treatments it lost 20° at the rate of 20° per treatment. All in all, it gained (310°—20°)=290° in twenty treatments at the rate of 14.5° per treatment.

Table I, which is self-explanatory, summarizes in detail the various treatments and their effects.

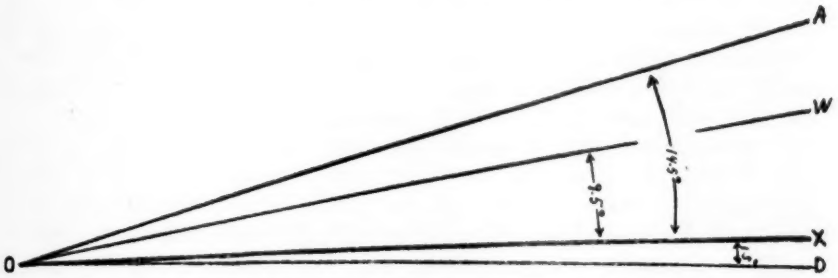
TABLE I

	No. of Treatments	No. of Times Treatment Resulted in Gain	Total Gain	Average Gain	No. of Times Treatment Resulted in Loss	Total Loss	Average Loss	No. of Times Treatment Produced No effect	Average effect of all Treatments
DIATHERMY									
1. As first treatment	24	12	91°	7.6°	10	55°	5.5°	2	$\frac{91-55}{24}$ equals 1.5°
2. As second treatment following whirlpool	24	7	25°	3.6°	14	101°	7.2°	3	$\frac{25-101}{24}$ equals −3.0°
3. As second treatment following hot air	12	1	5°	5.0°	10	55°	5.5°	1	$\frac{5-55}{12}$ equals −4.5°
4. Regardless of sequence	60	20	121°	6.0°	34	211°	6.5°	6	$\frac{121-211}{60}$ equals −1.5°
WHIRLPOOL									
1. As first treatment	30	26	287°	11.0°	2	18°	9.0°	2	$\frac{287-18}{30}$ equals 8.9°
2. As second treatment following diathermy	18	17	186°	10.9°	0	0°	0.0°	1	$\frac{186-0}{18}$ equals 10.3°
3. Regardless of sequence	48	43	473°	11.0°	2	18°	9.0°	3	$\frac{473-18}{48}$ equals 9.6°
HOT AIR									
1. As first treatment	18	17	285°	16.7°	1	20°	20.0°	0	$\frac{285-20}{18}$ equals 14.7°
2. As second treatment following diathermy	2	2	25°	12.5°	0	0°	0.0°	0	$\frac{25-0}{2}$ equals 12.5°
3. Regardless of sequence	20	19	310°	16.3°	1	20°	20.0°	0	$\frac{310-20}{20}$ equals 14.5°

From the above table the following interesting ratios as to the effectiveness of the different treatments might be made:
As the *first* treatment—hot air : whirlpool : diathermy :: 14.7 degrees : 8.9 degrees : 1.5 degrees
Regardless of sequence—hot air : whirlpool : diathermy :: 14.5 degrees : 9.6 degrees : −1.5 degrees

FIGURE 1

True angular representation of the average effect per treatment of diathermy, whirlpool and hot air, regardless of sequence.



Angle XOA equals average influence of 20 hot air treatments equals (plus 14.5 degrees).
Angle XOW equals average influence of 48 whirlpool treatments equals (plus 9.6 degrees).
Angle XOD equals average influence of 60 diathermy treatments equals (−1.5 degrees).

PHYSIOLOGICAL IMPLICATIONS OF THIS STUDY

It would seem evident, in trying to re-establish normal motility in a joint, that the FIRST treatment applied must have the advantage in producing desirable results; because, in regaining ten degrees of flexibility for instance, it is obviously easier to produce the gain of the first than of the last, or tenth, degree. This should be true particularly in applying two or three treatments in immediate succession as has been the practice in these experiments. It is interesting to note, therefore, that it was when applied as the FIRST treatment that diathermy produced a gain—an average gain of 1.5 degree per treatment. In all other cases, when it was applied immediately after whirlpool or hot air, its average effects were negative; following whirlpool it lost at the rate of 3 degrees per treatment; and following hot air, it lost at the rate of 4.5 degrees per treatment. On the other hand, whirlpool produced its greatest gains when applied immediately after diathermy; hot air was applied in immediate sequence to diathermy only twice, which is not enough from which to draw a fair average, but in these two instances the gain averaged 12.5 degrees per treatment. We are mentioning these facts, especially in regard to the diathermy-whirlpool relation, because, as we have previously stated, some of our present-day authors advise that whirlpool should be given immediately before diathermy so as to "prepare" the limb or joint for the latter treatment. They do not, however, give any reason for this "preparing" nor its physiological significance. From the results obtained here, it would seem that if there is any "preparing" to be done, it should be by giving diathermy before whirlpool and not vice versa, at least if increased motility and softening of tissues are the desired effects.

We cannot evade the question: Why the difference in effect from these various treatments? No pretense of giving a final answer to the question is made here, but the following line of reasoning presents itself:

A swollen joint is generally a stiff joint; but, we believe, only in case the swelling is of a pathological origin, that is, if the swelling is caused by a more or less localized exudate. However, a limb or joint may also swell (increase in volume) by a general increase in vascularity—a general vasodilation—and under such conditions it may actually be more flexible than it was before. Such results are obtained, for example, when excessive hyperemia, vaso-dilation, is produced by subjecting the limb or joint to heat treatments. We wish to emphasize this point because of the commonly heard statement that swelling (increase in volume due to excessive amounts of blood and lymph) in itself constitutes a cause for stiffness. We are inclined to believe that under some conditions, vaso-dilation (swelling) does not prohibit freedom of motion.

We are then confronted with the fact that vaso-dilation (swelling), increase in volume of a part, may or may not be accompanied by stiffness. One must, therefore, look elsewhere for the true cause of the stiffness. It is interesting to note in this connection that massage, which most certainly produces increased circulation and vaso-dilation, does not necessarily influence the motility to any marked degree, especially when applied after heat treatment. The greatest effect of massage on the subnormal motility of a joint seems to be when it is applied as the FIRST treatment for the purpose of removing some localized exudate and is followed by passive movements. How are we, then, to explain these apparently contradictory results: In one case vaso-dilation produced by one means, hot air, with a greatly increased motility; in another case, vaso-dilation produced by different means, massage, with no appreciable effect on the motility? A closer scrutiny of the immediate gross physiological effects of these two treatments may reveal the reason. In the case of the heat treatment, there results: (1) an increased circulation *to* the treated area, (2) a "semi-passive" hyperemia, and (3) an *increase* in the volume of the limb. In the case of massage there results: (1) an increase in circulation both *to* and *from* the treated area, (2) an active hyperemia, and (3) a *decrease* in the volume of the limb.

We have, then, the two somewhat similar effects of increased circulation and hyperemia in both cases; and the dissimilar effect of increase and decrease in volume, and the somewhat unexpected result that greater motility accompanies the increase in volume. This, however, does not necessarily imply that the increase in volume is the cause, directly or indirectly, of the increased motility, because

they may both be the effect of a common cause. If the latter be true, we are forced to conclude that the heat treatment is that common cause; and personally, we are inclined to take that view.

In order to justify in some degree this viewpoint, we shall seek to explain the underlying physiological reactions through the difference in flexibility of the two "swellings"—the pathological one and the "heat produced." In case of the pathological one, the swelling is produced by a stagnation of the circulating fluids of the body: these fluids, because of some injury to the tissues, flow into and between the tissues and thus produce a tension upon the surrounding tissue structure, both normal and pathological. This abnormal tension, augmented by "protective" spasms, then, prohibits a free and normal motility of the joint involved.

In case of the applied heat, what is the cause of the swelling? The increased vascularity, of course. But the fluids which have accumulated in the treated area exert a pressure on the surrounding tissues in this case also. These tissues are consequently also stretched considerably, but nevertheless, there is greater motility; and it is to be noted that such an increase in motility is also obtained by heat treatments in the case of injured joints, such as sprained ankles, with the usual localized exudates.

In regard to the increased motility obtained by the heat treatments, we can, therefore, see but one answer: The heat produces a vaso- and muscular loss of tone; or, in general, a loss of tone in the whole tissue structure. Then, with this loss of tone present, the blood and other body fluids which are constantly under pressure naturally flow into this region of least resistance. Similarly, this loss of tone of the tissues gives them greater elasticity, which, in turn, allows greater motility.

We conclude, therefore, that vaso-dilation and increased motility are not here physiologically related except in that they are both effects of a common cause, the heat treatment. However, it appears safe to conclude further that only those treatments which produce vaso-dilation through a general loss of tissue tone in the part treated bring about a simultaneous increase in motility. Massage, for example, may bring about vaso-dilation, but it does not do so through a general loss of tissue tone in the part massaged, but rather through the mechanical stimulation of the circulation, and as a consequence, does not necessarily produce greater motility.

One is now forced to ask: Does diathermy produce a similar loss of tissue tone? If not, why not?

Our results give a negative answer to the first question.

The answer to the second part of the question may be made in two steps: first, does diathermy really heat the tissues; and second, if heat is produced why not also greater motility? The answer is

that heat is produced in the part treated—often considerably so, especially in the neighborhood of the applied electrodes or in constricted areas between them. How penetrating this heat is, we are not prepared to say. There seems to be considerable difference of opinion on this matter among investigators. But we may safely say that heat is produced, and that, in general, there is no increase in motility.

The following question, then, naturally arises: Does diathermy produce hyperemia, vaso-dilation, and an increase in the volume of the part treated? From our observations, we feel safe in saying that hyperemia is generally produced, especially near the electrodes; slight vaso-dilations have at times been observed in areas between the electrodes; and as a natural consequence of the latter observation we conclude that there is, on those occasions, a slight increase in volume; but, in general, we have never observed any hyperemia, vaso-dilation or increase in volume of the treated part anywhere near as great as would be observed after whirlpool or hot air treatments. These are statements of general observations and not quantitative measurements; however, we are pursuing such quantitative measurements at the present time and hope to have definite data in regard to them in the near future.

In this failure to produce tissue relaxation, then, lies the explanation of diathermy's negative influence on the motility. But one asks further: Since, without doubt diathermy does produce heat in the tissues, why does not tissue relaxation follow?

Before discussing this phase, we quote from Christie: "The only constant effect which is known to be produced by high frequency alternating currents is that of heat production. The chemical effects of electrolysis disappear as the alterations exceed a frequency of 5,000 to 10,000 per second. The explanation for this fact lies in the rapidity of reversal of the current, which does not allow the chemical action of one phase to manifest itself before it is neutralized by the opposite phase. The absence of any exciting influence on the tissues through which the current passes is probably analogous to this absence of chemical effect. If the high frequency current be so rectified that it is not alternating in character, electrolysis and muscular excitation will be produced, even if the frequency of interruption be as high as 500,000 per second."

In view of the above quotation, we are very hesitant to try to formulate any explanations. We do venture, however, to submit the following suggestion: In their general applications, electric currents are stimulative—never sedative—to both motor and sensory mechanisms simultaneously. One may conclude, therefore, that whenever these currents do react in any noticeable manner, the ten-

dency would be to produce muscular contractions or increased nervous excitability, and not the reverse.

In the case of diathermy, the period of stimulation is so short that it falls safely below the chronaxie; however, might it not be that the chronaxia, after all, is not an *absolute* limit of the muscular reactivity to electrical stimulation? Is it not possible that, although the chronaxia does indicate the demarcation of an *immediate* reaction of the tissues to the electrical stimuli in form of contractions, there may occur, upon prolonged application of sub-chronaxia stimuli, a summation of these stimuli, which, although they do not cause a typical contraction, do bring about a slight rigidity in the tissues so stimulated? At least, it would seem more logical to deduct from the general reactivity of electrical currents that, if they react at all, the reaction would be one of rigidity and contraction rather than of relaxation. This deduction is further substantiated by the results of our experiments; namely, that whenever diathermy is applied to tissues which have been brought to maximum relaxation through whirlpool or hot air, there is almost invariably a reaction of rigidity. In fact, as already indicated, diathermy when applied immediately after hot air treatments, produced an average loss of motility of 4.5 degrees per treatment.

From these observations we feel justified in taking the view that the failure of diathermy to produce an increase in motility of injured joints lies, not in an inability to raise the temperature of the part treated, nor in a failure to produce a hyperemia (because we have observed both of these effects), but rather in the fact that it tends to produce a rigidity in the tissues treated. We feel, too, that this reaction of rigidity is in reality greater than it at first appears, because the heat produced by diathermy naturally tends to relax the tissues and thus counter-act the rigidity effect of the current; and as observed, when diathermy is applied as the FIRST treatment, i. e. not *preceded* by any other treatment, there occurs a slight relaxation, but when the tissues have been previously relaxed by a heat treatment, the rigidity influence becomes, by far, the most dominating.

In general, we have found that this rigidity increases with the intensity of the current applied and the duration of the treatment. We have failed to observe any sharp contrast between so-called "sedative" and "stimulative" technic as advocated by Sampson and others.

The above discussion is based on the assumption that normal flexibility of joints was prevented by stiffness, rigidity, "protective" spasms, etc., of the tissues involved. There exists, however, another important factor, namely that of *pain*.

Because of its subjective nature, the individual variation in tol-

erance or fortitude, and the impossibility of quantitative measurements, the extent to which pain limits voluntary movements of injured joints, muscles or ligaments is difficult to evaluate.

In some cases, as for example injuries to the flexors of the knee, one may wonder whether pain reflexively limits the movements or whether it is limited by a muscular "mechanical" inefficiency due to a lesion, and whether pain sets in only after the temporary physiological limit of flexion has been reached.

However, in such cases as injury to the median collateral ligament of the knee, there is no evidence of actual injury or stiffness of the flexor muscles; but flexion is nevertheless arrested, and it would seem chiefly by pain initiated by tension on the injured ligaments. Indeed, it would be difficult to conceive of such an injury producing a stiffness sufficient to resist the pull of the flexors. In either case, however, one may wonder as to whether movement is arrested chiefly by pain or by stiffness; and as to whether or not the application of heat reduces the pain by partial elimination of the stiffness or through a more direct action on the pain mechanism.

At present nothing can be stated about the way in which heat (hot air, hot water) applied to the skin reduces the irritability of the pain mechanism.

SUMMARY

In trying to restore normal motility in joints after "athletic injuries":

1. Hot air is the most efficient medium. It should be applied for not less than forty minutes.

2. Whirlpool treatments are somewhat less efficient than hot air, but they produce their maximum effects in much shorter time. Ten to fifteen minutes is generally sufficient.

3. Diathermy gives a very slight increase in motility if not preceded by other heat treatments. When applied after other heat treatments it produces a distinct decrease in motility. In either case, movements are for some time apt to be more painful after the diathermy treatment than before; this pain is immediately removed, however, by submerging the aching limb in hot water or whirlpool bath.

4. We attribute the reason for the negative influence of the diathermy treatment to a muscular rigidity produced by the passing of the high frequency current. Whether or not this rigidity is of a muscular or neuro-muscular nature, direct or reflex, we are unable to state. The rigidity tends to increase with the intensity of the current applied and with the duration of the treatment.

5. Whenever the aim is to produce relaxation of tissues, or reduce stiffness of joints, the most *effective* method is hot air; the most *rapid* is hot water or whirlpool. Diathermy, if applied, should be applied alone, or be *followed* by whirlpool or hot air applications. In either case, it should be applied briefly and with a current of small intensity.

6. Massage, especially if applied after heat treatments, does not materially influence the motility. It should be applied briefly and gently—especially during the acute stage of the injury.

7. Passive movements, as well as active exercise, materially increase the motility, provided they are not performed too strenuously.

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Testing and Scoring the Physical Efficiency of College Women*

By Agnes R. Wayman

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WE hear much about efficiency these days, about efficiency experts, the efficient life, etc., and those of us who are physical educators hear much about physical efficiency. Those of us who are especially interested in tests and standards and tables for measuring physical efficiency, will, I am sure, agree that it is just about as complex a quality as intelligence to measure. Like intelligence it is dependent upon no one quality, and just as no one test will measure intelligence, so no one test, I am sure, will measure physical efficiency. The general tendency in education at present seems to be to measure everything by arbitrary standards, because personal judgment is too inaccurate, and students are now being admitted to many colleges by means of mental tests. I hope the time will come—and I think it will—when a boy or girl will have to pass a certain physical efficiency test also, not merely present a physician's written statement of absence of disease. Then we shall not have to nurse so many students through college; then the secondary schools and primary schools will take notice; the school boards and city governments, state boards and parents will take notice; and the proper equipment, instruction, and attention—with time for it—will be furnished. I learned lately that Franco-American scholarships are being refused to girls who have a poor health record—which is a step in the right direction.

Upon the other hand, I think we are in some danger of *over-standardizing* and *over-testing*—or at least of depending too much on the results of tests as expressed in figures. We are apt to take them too literally, and not pay enough attention to that elusive something—that fourth dimension in a human being which turns failure into success, and to overlook the influence of the moral and social qualities we are trying to develop which do not lend themselves so easily to measurement. However, I do not think that this over-indulgence for testing and measuring applies to physical efficiency tests—only as we have misinterpreted the words "physical efficiency." Perhaps it might not be amiss to define the word "efficiency." The dictionary defines it as (1) the power of action, the act of producing effects; (2) from the point of view of mechanics, it is the ratio of energy or work that is gotten out of an engine, a storage battery, or the like, to the energy put in; (3) political economy defines it as productive activity, the

* See note at end of article.

power of producing wealth. All of these definitions indicate that to be efficient is to be able to produce. The dictionary further defines "efficient"—the adjective—as "characterized by energetic and useful activity, effectual, competent, capable."

In our tests, then, what we are after is some means of measuring an individual's power to produce, his effectiveness, his power of action, and we are to measure this by the physical means at our command. We are to establish certain standards, and then, since it is in our province, to further develop that individual by physical activities, advice, medical attention, etc., until, if possible, she does measure up to a certain standard. An individual to be absolutely efficient, must, to my mind, be in good health as we interpret good health, be sound organically, have no defects of feet or posture, have good health habits, be possessed of endurance and strength, be well poised, be possessed of certain neuro-muscular control as exhibited by reaction to certain motor ability tests, these tests to include the fundamental activities—running, jumping, throwing, and climbing—or combinations or variations of both.

As I have studied so-called physical efficiency tests in use in various places for the past few years, in Y. W. C. A.'s, primary and secondary schools, and colleges,—also the reports of the various committees—it has seemed to me that the tests were not physical efficiency tests, but merely proficiency or motor ability tests, and that if we are to have real efficiency tests, they must determine, and take cognizance of an individual's physical deficiencies as well as his motor deficiencies. If there are motor deficiencies there must be physical or mental reasons for them, and a real physical efficiency test would tend to show the physical reason. Then, using this as an intelligent basis for procedure, we should treat the primary cause before attempting to improve the motor deficiencies. A girl with flat feet, a poor posture, and suffering from malnutrition cannot be expected to cover herself with glory in a motor ability test.

For a number of years I have reported at the annual meeting of the Eastern Association of College Directors of Physical Education for Women on the work which I have done each year along this line, and it has been through their co-operation and interest and the tests which they have used as an experiment that my results have been made possible. I suggested that we work out and adopt tests which would more or less accurately measure a girl's physical condition and ability, and as a result of which we could give her a score which would represent her physical score or P. Q. just as a psychologist by a series of mental tests is able to give an individual his I. Q., or Intelligence Quotient. Up to this time at Barnard College we had been using a crude motor ability test in conjunction with a posture grade, a health rating, and a gymnastic rating, the passing of which allowed

a student to elect her own type of physical activity, in place of the required so-called "formal gymnastics." A freshman could not take the test. Finally, as chairman of a committee composed of Dr. Gilman of Smith College, and Miss Lina Niles of Bates College, I sent out letters to forty colleges, asking them to experiment with what they considered physical efficiency tests, and let me have the results. We did not specify the kind of tests as we wished to get the individual belief and reactions of the various physical directors on that point.

These reports indicated that the majority of colleges were using no tests, two were experimenting with Dr. Sargent's so-called "pep" test, one was using a grading system on the basis of points for health habits—posture, feet, weight-height index, lung capacity, total strength and subcostal angle. One was using tests and giving honors. Many I did not hear from.

Dr. Gilman of Smith, Miss Brownell of Wisconsin, and I were agreed that the final score must represent a *series* of tests, or a *team* of tests, rather than just a motor ability test, if we were to measure physical efficiency.

In connection with this I made some little study of intelligence tests and methods of scoring. As you know the I. Q. scores run as follows:

$$\frac{\text{Mental age}}{\text{Chronological age}} = \text{I. Q.}$$

Above 140, Genius or near genius.
120-140, Very superior intelligence.
110-120, Superior intelligence.
90-110, Normal or average intelligence.
80- 90, Dullness.
70- 80, Borderline deficiency, sometimes feeble-minded.
Below 70, Definitely feeble-minded.

My plan was eventually to work out tests which would give accurate scores paralleling this scheme, so that a girl with a given score would be either,

1. Of very superior efficiency.
2. Of superior efficiency.
3. Of normal or average efficiency.
4. Slightly subnormal.
5. Inefficient.

With these things in mind, I worked out my tests. It did not seem possible to work out one table which would include them all. Possibly because of the way in which our work is divided at Barnard, it naturally fell into three separate sets of tests and scores—the medical score, the anthropometric score, and the motor ability score. The

Key for Scoring Medical Test for College Women

Arranged by AGNES R. WAYMAN

Professor of Physical Education, Barnard College, Columbia University

POINTS	E-1	D-2	C-5	B-8	A-10
Ht-wt. ±	26-30	21-25	16-20	11-15	0-10
Haemoglobin	70-74	75-79	80-84	85-89	90-100
Heart	E	D	C	B	A
Lungs	E	D	C	B	A
Menses	Great Pain and irreg.		Some pain and irreg.	Nearly normal	Normal
Constipation	Laxative daily		Laxative weekly	Nearly normal	Normal
Eyes	E	D	C	B	A
Teeth	E	D	C	B	A
Nose and Throat	E	D	C	B	A
Ears	E	D	C	B	A
Skin	E	D	C	B	A
Glands	E	D	C	B	A
Posture	C to D	C+ to C	B to B−	A− to B+	A
Feet	C to D	C+ to C	B to B−	A− to B+	A
Hygiene of Body	E	D	C	B	A

Maximum Possible Score 150 points

Normal Score for College Freshmen 130 points

New Key for Scoring Anthropometric Test for College Women

Arranged by AGNES R. WAYMAN

Professor of Physical Education, Barnard College, Columbia University

POINTS	1	2	3	4	5	6	7	8	8.5	9	9.5	10
Lung Capacity	130 cu. in. to 145 cu. in.	146 to 160	161 to 170	171 to 180	181 to 200	201 to 210	211 to 220	221 to 230	231 to 240	241 to 250	251 to 260	261 to 270
Chest Expansion	1″	1.5″	2″	2.5″ to 2.8″	2.9″ to 3.5″	3.6″ to 3.8″	3.9″ to 4″	4.1″ to 4.2″	4.3″ to 4.4″	4.5″	4.6″	4.7″
9th Rib Expansion	1″ to 1.5″	2″	2.5″	2.6″ to 3″	3.1″ to 3.8″	3.9″ to 4″	4.1″ to 4.2″	4.3″ to 4.4″	4.5″	4.6″	4.7″	4.8″
Strongest Grip	40 lbs. to 50 lbs.		51 to 55	56 to 60	61 to 65	66 to 70	71 to 80	81 to 85	86 to 90	91 to 95	96 to 100	101 to 105

Maximum Possible Score, 40 Points

Normal Score for College Freshmen, 18 Points

Normal Score for College Freshmen, 18 Points

first two might have been combined, but for my own purpose I preferred to keep them separate.

(1) The medical test contained fifteen items, height and weight ratio (allowing 10 per cent variation), haemoglobin count, heart, lungs, eyes, teeth, nose and throat, skin and condition of the hair, menstruation, bowels, posture and feet.

(2) The Anthropometric Test contained four items, lung capacity, chest expansion, ninth rib, and right grip. I was somewhat hampered by the fact that I was limited to tests and measurements which could be given by the majority of colleges.

(3) The Motor Ability Test and score presented many problems and difficulties, and as was the case with the other two, was far from satisfactory. We wanted a series of tests based upon the fundamental activities—running, jumping, throwing and climbing, whose object was to enable us to classify more or less accurately a college girl as "Very Superior," "Superior," "Normal," "Subnormal," or "Inefficient," according to her physical ability as demonstrated by participation in certain motor activities. The body was to be given a number of stunts to do, the success of which would be dependent upon the qualities we were testing for. By the reaction to these tests the proficiency of the body and the neuro-muscular system would be rated. Therefore, by arbitrarily ssigning a certain rating to each test, standardizing the tests, and the method of conducting them as nearly as possible, by adding all of the results for all the activities, we would have the motor ability score. The scores in each test ran from one to ten points.

As the Medical Test contained 15 items, a maximum score of 150 points was possible; 4 items in the Anthropometric Score made a possible maximum score of 40 points; and 8 items in the motor ability made a possible maximum of 80 points—making a total possible Physical Efficiency Score of 270 points. The question to be settled was: What is "normal"—what "highly efficient"—what "inefficient," etc. The whole problem was difficult and confusing because we were testing for the very qualities we were trying to develop.

The psychologists recognized the same thing in working out the mental tests, and so they devised a number of different kinds of tests. The two which interested me most as related to our problem were the Intelligence Tests and the Achievement Tests. The intelligence tests are designed to measure general intelligence. They aim to test innate mental ability or brain power, and are not dependent for results upon education. They test the basic thing upon which education and success in life are dependent. It seemed to me that that was the sort of motor ability test that we were after—one which would be a simple standard of measurement of the girl's ability at the time, regardless of previous training or lack of training—simple enough so that with

New Key for Scoring Motor Ability Test for College Women

Arranged by AGNES R. WAYMAN
Professor of Physical Education, Barnard College, Columbia University

POINTS	1	2	3	4	5	6	7	8	8.5	9	9.5	10
Running High Jump	1′ 6″ to 1′ 11″	2′ to 2′ 5″	2′ 6″ to 2′ 10″	2′ 11″ to 3′ 2″	3′ 3″ to 3′ 6″	3′ 7″ to 3′ 9″	3′ 10″ to 4′	4′ 1″ to 4′ 3″	4′ 4″ to 4′ 5″	4′ 6″	4′ 7″	4′ 8″
Basket Ball Throw for distance	16′ to 20′	21′ to 25′	26′ to 30′	31′ to 35′	36′ to 40′	41′ to 45′	46′ to 50′	51′ to 60′	61′ to 65′	66′ to 70′	71′ to 75′	76′ to 80′
25 yd. Dash	6.4″ 5 4″	5.3″ 5.2″	5.1″ 5″	4 4″	4.3″	4.2″	4.1″	4″	3 4″	3.3″	3.2″	3.1″
Buck for height			3′ 3″ 3′ 5″	3′ 6″ 3′ 8″	3′ 9″ 4′	4′ 1″ 4′ 2″	4′ 3″ 4′ 6″	4′ 7″ 4′ 11″	5′	5′ 1″	5′ 2″	5′ 3″
Ropes for height		2′		4′	5′	6′ 10′	11′ 20′	21′ 25′	26′ 29′	30′ 33′	34′ 36′	37′ 40′
Boom balance walk for form	1 pt.	2 pts.	3 pts. 4 pts.	5 pts. 6 pts.	7 pts. 8 pts.	9 pts. 10 pts.						
Tumbling agility, coördination				Forward roll	Back-ward roll			Head stand	Hand stand	Cart Wheel		Hand Spring
Gymnastics form, response, coördination	1 pt. 3 pts.	4 pts.	5 pts.	6 pts.	7 pts.	8 pts.	9 pts.			10 pts.		

Maximum Possible Score, 75 Points
Normal Score for College Freshman, 32 Points

PHYSICAL EFFICIENCY SCORE

Barnard College

NAME_____ CLASS_____

Maximum Medical Score 150—Normal 130 Maximum Anthropometric Score 40—Normal 18	DATES			
MEDICAL SCORE In Points				
Ht. wt. age ratio				
Feet				
Posture				
Teeth				
Nose and Throat				
Eyes				
Ears				
Glands				
Skin—condition of				
Haemoglobin				
Heart				
Lungs				
Bowels				
Menses				
Hygiene of body				
Incl. hair and nails				
Total (1)				

Maximum Motor Ability Score 75—Normal 32 Maximum Total Score 265—Normal 180	DATES				
ANTHROPOMETRIC SCORE In Points					
Chest expansion					
9th rib expansion					
Lung capacity					
Grip—right hand					
Total (2)					
MOTOR ABILITY SCORE In Points					
Running high jump					
Basket ball throw					
25 yd. dash					
Buck					
Boom					
Ropes					
Tumbling					
Gymnastics					
Total (3)					
GRAND TOTAL=1+2-3-PQ					

CONSULT YOUR KEY SHEETS FOR THE VALUE OF EACH TEST. FILL IN ABOVE THE NUMBER OF POINTS INDICATED THERE. THE NORMALS AT TOP OF CARD REPRESENT AVERAGE SCORES FOR COLLEGE FRESHMEN (GIRLS).

AGNES R. WAYMAN.

accurate directions she could take the tests without practice. Of course, the girl with previous training would have the advantage and probably would rank higher, but not necessarily so, and that is exactly what we wanted to find out. We were testing not merely for inches and feet and seconds and height, but for the qualities which would make these things possible and make them little or much —such qualities as endurance, speed, strength, coordination, balance, control, agility, skill, courage, time reaction, etc. Having secured these results in figures as a result of her performance in these various activities, it seemed it might be possible to go a step further, and by adding together and averaging the scores in the various events which require coordination, give the girl a mark in coordination instead of in the activity, and the same with speed, agility, courage, etc., the sum total of all these scores to represent her actual motor ability score. Of course, I realized that all of these activities overlapped, and that most of them were dependent upon more qualities than one in their performance; but by picking out each activity predominant in a certain quality, would it not average up in the end, and be fairly accurate?

The achievement tests used by the psychologists test an individual's progress in the different subjects, furnish a definite goal, and act as a stimulus for improvement. Having worked out our initial motor ability test, it ought to be simple to work out so-called achievement tests, which would be a goal to work toward for an individual or a group or a class or a college, the degree of efficiency one might hope to attain or ought to obtain after one year or two or three years of practice along certain lines, and is the next logical step, I think.

This scheme and these tests were later presented at the college directors' meeting at Bryn Mawr, and in spite of apparent weaknesses, it was decided to adopt it, try it out, and as a result of the statistics obtained, correct it.

About twenty-five colleges ordered the key sheets for scoring and the final score sheets. Only seven turned in statistics, and not all of these were complete. In obtaining my "Normal" scores for each group, I could use only results where the student had been subjected to all the tests, which reduced me to about 1,000 cases. In obtaining the averages in each separate test in a group, I had from 700 to 1,500 cases, varying in different tests. I had two problems:

1. To use the statistics obtained so as to get averages or normals for each of the three groups, and for each event or test in the Anthropometric and Motor Ability groups, which could be used as standards in each test or event. The sum total of these group averages was used to represent the Normal Physical Efficiency Score—that is, the sum of the Medical, Anthropometric, and Motor averages.

2. To obtain the number measured or tested in each activity in

the Motor Ability group and in each test in the Anthropometric group, and the number which failed at each step, using the percentile tables already compiled in Rugg, "Statistical Methods Applied to Education," in order to correct my present score and test sheets so that the same number of points in each test would represent the same degree of difficulty and the minimum point on each activity would correspond with the minimum in another—the maximum in one activity with the maximum in another. My problem was simplified by the fact that I was dealing with adults and did not have to consider age, height, or weight.

I. Order of Procedure:

1. By adding the Medical Scores in each college and dividing by the number examined, I found the Medical Average. I used only cases where the student was fully examined. I did the same with the Anthropometric group and Motor group.

2. I did the same with lung capacity, chest expansion, ninth rib, and grip for each college, and by adding the average lung capacity for each college, the average chest expansion, the average ninth rib and average grip, obtained the average score in each of these tests. By translating the number of points represented in each "Normal" back into the pounds, cubic inches, or inches represented by that score, I obtained the *average lung capacity, chest expansion, ninth rib,* and *grip.* So we have these averages in *points, pounds, inches,* and *cubic inches.*

3. I followed the same system for the Motor Ability tests—I found the averages for each college in each event; by adding the total averages in each event, and dividing by the number of colleges, I found the average for each event in points and then translated these points into feet, inches, seconds or points according to the score sheet used this year.

II. Solving the second problem:

1. The averages were true, but the point system was not. The most difficult problem was therefore to rearrange the point system. This I did in the following way: Using the present score sheet I found the number who passed at each step in each event, and the number who failed at each step in each event. Miss C. Dowd of Byrn Mawr then computed the percentiles, using the principle of the normal distribution curve, the actual performance being used in each case instead of the number of points made. The results were most interesting—the averages in each case fell at about four points. Now notice the difference: *high jump*—2′6″-2′10″ (our first height)—now receives three points instead of one—giving one point to 1′6″-1′11″, and two points to height 2′-2′5″—which was needed as 122 out of 950 failed to jump 2′6″. The *basket ball throw* likewise was also found much out of proportion—(31′-35′ now receiving four

points instead of one) and is graded down to 16 feet, as 286 failed to pass the 31′.

The *dash* was rated too liberally—5.4″ instead of receiving four points should receive one, and 3.1″ receive ten. Only 13 failed, and 265 got six points each.

Ropes was the most difficult and unsatisfactory event to deal with as the majority failed to climb even the first height indicated, four feet. According to the rearranged scale, four feet received four points and the event started with two points for a two foot climb.

Three feet, three inches in *buck* instead of receiving one point now receives three points and no points for less, as that is the lowest height of buck.

The *boom* is more condensed, and receives only six points for a ten point mark, ten points in the boom being too easy to secure in proportion to 10 points in other events. Only 69 failed, and 329 got ten points each.

Tumbling groups itself in an interesting way. Forward roll is rated at four instead of two. Backward roll at five, and head stand, hand stand, and cart-wheel at eight, eight and one-half and nine respectively—none being granted a ten. I have added a hand spring for that.

Gymnastic points are also grouped according to value, or difficulty—six points getting only a four, and ten points only a nine—there being no ten score in this. This reduces the whole possible score in motor ability to seventy-five instead of eighty. So this is the corrected score. I did the same with the Anthropometric score.

As a result of these statistics, we know that in order to be average, a college freshman should have a lung capacity of 170 cubic inches, chest expansion of 2.6″; ninth rib 2.8″; grip of 60 pounds. She should be able to jump 3′2″; throw a basket ball 35′; run a 25-yard dash in 4.4″; and vault a height of 3′8″. She should be able to climb 4 feet; she should get a score of six points in the 3-foot boom for balance; be able to do a forward roll easily and get six points in a short day's order. Her total Medical Score should be one hundred thirty points, Anthropometric Score eighteen points, Motor Ability Score thirty-two points, and her Total Score, or *Physical Efficiency* Score, should be one hundred eighty points out of a possible two hundred sixty-five. That is *normal*. Shall we then say:

226-265, highly efficient.
181-225, superior efficiency.
166-180, normal.
151-165, inferior efficiency.
150 or below, inefficient.

Having obtained these results, the final test is—How do they correlate with the judgment of the physician or the instructor, for

after all, that is the final test. Why, then, you may ask, do we go to all this bother? Because an accurate test will enable us to find out in one or two hours what it might take a year to find out if we waited for the judgment of the teacher.

Having once formulated our tests, the uses to which these tests may be put are many, as for instance:

1. To enable a student to know her exact rating, and as a result of that rating and what it indicates, to assign a girl to the type of work she needs. And that is one reason I prefer simple tests which require no special preparation or practice, so that all freshmen may be tested at the time of the medical and physical examination , or as soon after as is convenient, and these results made a basis for allowing a girl to select her physical work after one semester if she tests high enough. Then, too, these same tests may be used as proficiency tests to a certain degree, and by retesting a girl at intervals, determine her advancement. Her physical education rating for the term might easily be based on her progress as represented by her scores at the beginning and end of the term.

2. To enable an instructor to divide a group of students who are "A" physically into the Normal, Subnormal, and Superior—or A. B, and C—groups, from a point of view of proficiency examinations.

3. To furnish a means of comparing individuals.

4. To furnish a means of comparing groups or classes.

5. To furnish a means of comparing colleges or groups in one college with a corresponding group in another college.

6. To furnish an incentive for improvement or achievement.

7. To furnish a means of testing improvement or achievement.

8. To furnish a means of deciding whether or not a student can be excused from specialized training along certain lines and allowed to elect her work.

9. To furnish a basis for classifying pupils for special attention.

10. To aid in pointing out students in need of special attention.

11. To furnish a basis for correlations of all kinds, such as:

a. What is the correlation between the teacher's judgment and the test score?

b. What is the correlation between the Medical Score and the Anthropometric, or the Medical and the Motor Ability, or the Anthropometric and the Motor Ability?

c. Is there a correlation between the physical condition and physical proficiency?

d. What is the correlation between mental ability or intelligence and proficiency? Or what is the correlation between intelligence and physical efficiency? Is there any correlation? Do high Physical Efficiency scores coincide with high I. Q's? Do they correlate? Does the efficient mentality go with the efficient body in spite of a few exceptions?

e. Is there any correlation between posture and strength—between posture and lung capacity?

f. And finally, what is the correlation between test results and practical life results? That is the final test for all of our work.

I think that too much attention has been paid in the past to emphasizing *Motor Ability*, and not enough to improving *Physical Condition*. I have tried, by means of these score sheets, to interest the girl in her own problem, to try to make her compete against herself in raising not only her *Motor Ability* score, but the *Medical* and *Anthropometric* score, thus incidentally improving her physical condition. She has been making a game of it, a game in which she is pitted against herself and all her group, a game in which one group is pitted against another—one class against another, not only for highest individual and group score, but what is more important still, highest *Improvement* scores. We found these by retaking all tests in February. I call it a game of fitness, and by putting it on a play basis, I believe we'll really get somewhere. And we might base our rewards and awards on improvement, instead of highest score. Academic honors might include the Physical Efficiency Score. While giving the deficient girl something to fit her case and to struggle toward, we must not neglect to give the highly efficient girl work and play which is difficult enough. We are just as apt to err on that side.

Now that we finally have these averages, you can use the events you choose, if you don't care to use all. Another method of scoring would be to give each girl 100 per cent to start with—then add or subtract a point for each point she gets above or below the average in each event,—her final score to be the sum total of the pluses and minuses. The uses to which the results can be put are innumerable.

This article first appeared in the American Physical Education Review for 1923. There have been so many requests for it that all reprints and even the particular issues in which the article appeared have long been exhausted. Miss Wayman has kindly permitted the editor to reprint the material and has brought the study up to date by including the latest charts.

Mechanics and Kinesiology of Swimming

(The Crawl Flutter Kick)

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Introduction

The flutter kick is the swimming kick which is most widely taught at the present time. As a part of the elementary crawl stroke it is taught from the very first to beginners, and in a more vigorous and finished form is the kick used by all the fastest sprint racing champions. Yet, a survey of the literature shows that there has been practically no research to determine the underlying fundamental principles of body mechanics which makes propulsion with this kick possible. There are many points about which there are different opinions. The object of this paper is to present the fundamentals upon which pedagogy of the crawl flutter kick should squarely rest. An analysis of the kick as a problem in animal mechanics throws light upon many of its details, which undoubtedly will aid in clearing up many disputed problems and enable the instructor and coach to correct faults and explain difficulties in a more satisfactory manner.

Historical Development of the Crawl Flutter Kick

The outstanding features of the historical development of the flutter kick are briefly sketched so that its development may be related to the problems studied in this research. The detailed references to the literature involved are given so that a student interested in this particular phase may carry out more extensive reading if desired.

Preliminary Definitions

The exact origin of the word "flutter" as applied to the crawl kick is not known. Webster defines the word as meaning *to move with quick vibrations or undulations* and implies *quick and irregular motion.* Undulate means to move up and down in wave like motions. The flutter kick, therefore, may be defined as a swimming kick in which the legs are held fairly straight and move in a rapid succession of up and down oscillations, the feet producing an alternate wave like motion as the body travels forward. The word "beat" is used fre-

quently in swimming terminology to indicate a downward motion of a single leg. It might also be said that there would be an up-beat and a down-beat but throughout this exposition of the flutter kick the terms *up-kick* and *down-kick* are preferably used.

The Fore-Runners of the Crawl Flutter Kick

The flutter kick, or movements very like it, was used for quite a long time before the adoption of the crawl strokes. According to evidence available in the swimming literature, it was first used with the style of swimming known as QUADRIPED SWIMMING as described by J. Frost[1], in 1818. This stroke was executed essentially like our dog-paddle of today. The legs moved up and down in natural rhythm, the coordination being something like that of running on land. At any rate, this is the basis of the argument that the elementary crawl is the most natural for the beginner to learn. George Forrest[2] published a book in London in 1863 in which a stroke called CREEPING is described. The feature of this stroke was the horizontal position of the body, the method being used to extract one's self from weeds. In another edition of this book published by Routledge and Sons, London, 1872[3], the flutter kick as we now use it, both on the back and the stomach, was described. It was also used in the stroke called SWIMMING LIKE A DOG described in this same book. Beadle[4], in 1869, described a stroke called the STEAMER. It was essentially the flutter-back-scull performed on the back with a fast straight leg kick. This author remarks that some swimmers could make faster progress with it than swimmers using the whole stroke. Although this was more than thirty years before the invention of the Australian crawl by the Cavill brothers, there is no doubt that the crawl flutter kick movements were in common use as novelty events.

Invention of the Australian Crawl Brought Increased Use of the Flutter Kick

The story of the invention of the Australian crawl with its use of the narrow straight leg kicks is described by Sullivan.[5] Here it was discovered that Tums Cavill could really swim faster in sprint races with his feet tied. His brother, Dick Cavill, believed that this evidence indicated that the wide scissors kick was fundamentally wrong for racing, but remembering having seen Alex Wickham, of Rubiana, use a fast straight leg kick, decided to try it. It was reputed that Wickham learned this kick from the natives at

[1] Frost, J., "The Art of Swimming," London, 1816. (New York edition printed 1818.)
[2] Forrest, George, "Handbook of Swimming and Skating," Routledge and Co., London, 1863.
[3] Later edition same as above, 1872.
[4] Beadle, "Dime Guide to Swimming", New York, 1869.
[5] Sullivan, Frank, "The Science of Swimming" American Sports Publishing Co., N. Y., 1927, pp. 36-43.

Colombo, Ceylon. In 1902, Dick Cavill introduced the new stroke into England and defeated the best swimmers there over the short sprint distance. C. M. Daniels[6], the great American champion, writes that Gus Sundstrom, instructor at the New York Athletic Club, was indirectly responsible for the introduction of the crawl stroke into America because of his very efficient use of the flutter kick in a stroke called the SWORDFISH STROKE. In this the body was propelled through the water by a continuous action of the legs while the arms were held outstretched in front. According to Daniels, Sundstrom claimed that he got his wonderful power in the kick by relaxing the ankles and allowing them to bend freely.

Since this introduction into America, there have been varied uses of the kick. In 1903 the straight leg kick was considered a novelty in this country. Opinions varied about its usefulness. Some of the coaches were reluctant to give up the wider scissors action. The Australians claimed that the slower, more deliberate kick of their stroke was modified in America because of its unsuitability for fresh water tanks, the natural buoyancy of the water not being enough to keep the legs at the surface. Daniels was said to have copied the Australian kick but soon modified it to a kick of more continuous and faster action. According to Coach Kistler, of the University of Pennsylvania, who at one time trained him, Kahanamoku, the sprint champion for many years following Daniels, used this fast kick independent of any conscious timing with the arms. L. de B. Handley,[7] outstanding authority on the evolution of the strokes, describes how Frank Sullivan, as a prominent swimming instructor of Chicago, experimented with a combination of the fast flutter and the wider scissors kicks and developed several of the fastest swimmers in the world over intermediate distances between the 220 yard and 880 yard swims. The stroke became known as the TRUDGEON-CRAWL. Later the wide scissors kicks were used on both sides and the flutter movements used between, making a balanced six beat kick with two major beats. This is the stroke which is known as the American crawl stroke today. It is used over short and long distances, the major kicks being more pronounced when used with greater roll over the longer distances.

F. W. Luehring[8] edited a Symposium on the Crawl Stroke which is of interest because it shows the differences of opinion which centered around the type of kick to be used with the crawl. There were estimated to be at least ten kinds of crawl strokes, all distinguished by differences in the kick. All coaches were in agreement that the Australian crawl was obsolete and that a newer American

[6] Daniels, C. M., "Speed Swimming," American Sports Publishing Co., N. Y., 1907.
[7] Handley, L de B., "The Swimming Stroke of the Future". Outing Magazine, April 1914, pp. 99-103.
[8] See Intercollegiate Swimming Guide, 1922.

stroke had come to take its place as the fastest stroke. There were, however, many different opinions about the new stroke. Some claimed that it was performed with a four beat kick, others a six beat kick and the trend now is perhaps toward even more. As far as can be learned, there was no evidence published giving any objective data. Mr. L. de B. Handley has predicted that ultimately a much faster kick will prove to be the most efficient, perhaps twelve or fourteen beats per cycle of the arms. This is about as far as knowledge has gone regarding the flutter kick. Instructors are basing their instructions largely upon the meagre subjective material available.

The Major Problems of the Flutter Kick

The problems of the crawl flutter kick which are grouped in this research for solution may be outlined as follows:

1. Explanation of the Source of Power.
   (1) The Fishtail Action as an Explanation of Propulsion.
   (2) The Squeeze Action as an Explanation of Propulsion.
   (3) The Relative Value of the Up and Down Phases of the Movement.
   (4) The Relative Value of the Ankle, Knee and Hip Actions.
2. The Maximum Propulsive Force Developed in Pounds.
3. Regulation for Maximum Efficiency.
   (1) Ankle Action and the Position of the Feet.
   (2) The Amount of Knee Action.
   (3) The Width of the Kick.
   (4) The Rate of the Kick.
4. Kinesiology of the Crawl Flutter Kick.

There are several other major problems which have been purposely omitted from this study. (1) The Relationship of the Body Position to the Flutter Kick (2) The Problems Encountered When the Kick is Coordinated with the Armstroke and Breathing, such as Major and Minor Beats, Relative Value of Kick, Change in Rhythm, etc. These will be covered in specific studies to be published later. It should be clear then that the attempt in the present paper is not to cover all the problems of the flutter kick but to present a study of the fundamentals which should preceed the attack of the more difficult phases.

Explanation of the Source of Power

1. *Fishtail Action as an Explanation of Propulsion*

Statement of the Problem

The primary point is the question why a movement like that of the flutter kick will produce forward motion in the body of a swimmer in the water. The explanation prevalent at the present time seems to be that of the wedge action of the legs.

Explanation of Propulsion with the Flutter Kick

The true explanation of propulsion resulting from the flutter kick may be found in the action of the fishtail. One leg acting singly can produce propulsion because it acts considerably like the action of a fishtail. The fundamental laws of physics explaining propulsion in swimming are the same as in any other type of linear motion, namely, Newton's Laws of Motion.[9] The Newtonian Third Law of Motion states, "To every action there is an equal and contrary reaction." This simply means in swimming that if forward propulsion results, then the water must be pushed backward; the force available for forward propulsion is proportional to the force exerted in pushing the water backward. Forward momentum, neglecting the resistance of the water to forward motion, will equal in magnitude the momentum of the water pushed backward. Since momentum is the product of mass and velocity, it may be seen that both the volume of the water pushed backward and the speed with which it is pushed are important. One leg or one fishtail will produce forward motion if whipped back and forth like an oar sculling a boat from the rear. The direction of the movement in the case of the legs in the flutter kick is up and down rather than from side to side. However, it does not matter what plane the movement is executed in; the same movement will produce forward motion in any plane. In some fish-like forms, like the whales, for instance, the tail moves up and down rather than from side to side. Howell[10] may be quoted from his study of the mechanics of swimming among aquatic mammals as follows:

"Swimming by oscillations of the hinder end of the body (by feet or tail) is the most economical method partly for the reason that all motions are propulsive ones, without obligation of any braking action by recovery motions, and because each stroke of the rhythmic cycle is of approximately equal power."

Several authors have explained by theoretical diagrams the mechanics of swimming as illustrated by the action of the fishtail. Borelli[11] was the first of these and the diagram of his fish has been reproduced several times in other works upon animal mechanics. Borelli illustrated the principle of swimming used by fusiform (spindle shaped) fishes. In this style the tail is vibrated to either side of a given line, very much as a rudder is made to oscillate by moving its tiller. (see Illus. I-A). Pettigrew[12], in his classic work on animal locomotion written in Edinburgh in 1873, gives a most extensive analysis to the swimming movements as employed by the fish. Using

[9] May be found in any textbook of physics or mechanics, as Reed and Guthe, "College Physics", pp. 20-21, N. Y., 1919.
[10] Howell, A. B., "Aquatic Mammals", Chas. C. Thomas, Springfield, Ill., 1930, p 22.
[11] Borelli, "De Motu Animalium", Rome, 1680.
[12] Pettigrew, J. B., "Animal Locomotion", Appleton, N. Y., 1891, pp 64-74. (earlier edition by H. S. King and Co., London).

ILLUSTRATION 1

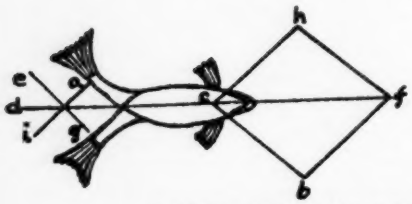

ILLUSTRATION I-A

SWIMMING OF THE FISH

(After Borelli 1680)

See Animal Locomotion, by J. B. Pettigrew, Appleton & Co., N. Y., 1891, p. 67.

DESCRIPTION OF BORELLI'S FISH:

When the tail strikes in the direction a i, the head of the fish is said to travel in the direction c h. When the tail strikes in the direction g e, the head is said to travel in the direction c b; these movements, when the tail is urged with sufficient velocity, causing the body of the fish to move in the line d c f.

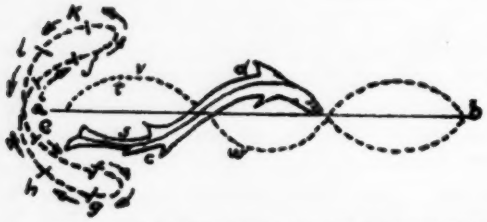

ILLUSTRATION I-B

SWIMMING OF THE FISH

(Pettigrew 1873)

Ibid., pp 68-69.

DESCRIPTION OF PETTIGREW'S FISH:

The anterior and posterior portions of the fish alternately occupy the positions indicated at d c and w v; the fish oscillating on either side of a given line, and gliding along by a sinuous or wave movement. The double curve is necessary to enable the fish to present a convex or non-biting surface c to the water during flexion when the tail is forced away from the axis of motion a b, and a concave or biting curve during extension when the tail is being forced with increased energy toward the axis of motion. It therefore describes a figure-of-8 track in the water as e f g h i j k l.

ILLUSTRATION I-C

SWIMMING OF THE FISH

(Wallace-Dunlop 1876)

See Plate Swimming by R. H. Wallace-Dunlop, Routledge & Sons, London

DESCRIPTION OF WALLACE-DUNLOP'S FISH

Propulsion is effected by passing the blade of the tail across the axis of progression with a rearward reflection of its effective side. The head wags in unison with the caudal movement, turning slightly to the side to which the tail is carried.

Borelli's diagram, he explains that Borelli's analysis is evidently a satisfactory one so far as it goes. Pettigrew maintains that a fish never throws its body into a single curve to one side but always into a double or figure-of-8 curve. (see Illus. I-B). The distinction between these two types of swimming by a fusiform body and an anguilliform (eel-like) body is described by Breder[13] and repeated by Howell[14]. For fusiform types which the human body more nearly resembles, Pettigrew agrees with Borelli in general principle as indicated by the following statement:

"In swimming, the body of the fish describes a waved track, the fish oscillating on either side of a given line, and gliding along by a sinuous or wave movement. The fish in swimming lashes its tail from side to side, precisely as an oar is lashed from side to side in sculling. It therefore describes a figure-of-8 track in the water. The tail is effective as a propeller both during flexion and extension, so that, strictly speaking, the tail has no back or non-effective stroke; the tail always operating, but being a less effective propeller when in the act of being curved than when in the act of being extended or straightened."

Pettigrew brings out a most important point about the action of the water swirls which follow the tail and increase its effectiveness:

"When the tail is moved outward, it draws a current of water after it which, being met by the tail when it is urged quickly in the opposite direction, enormously increases the hold which the tail takes of the water, and consequently its propelling power. The tail may be said to work without slip, and to produce the precise kind of currents which afford it the greatest leverage. In this respect the tail of the fish is infinitely superior as a propelling organ to any form of screw yet devised. The screw at present employed in navigation ceases to be effective when propelled beyond a given speed. The screw formed by the tail of the fish, in virtue of its reciprocating action, and the manner which it alternately eludes and seizes the water, becomes more effective in proportion to the speed with which it is made to vibrate."

Wallace-Dunlop[15] describes the swimming of the gurnet and the mackerel while commenting upon the descriptions as given by Borelli and Pettigrew. His description of observations made upon the gurnet is quoted as follows:

"The great head wags in unison with the caudal (tail fin) movement, turning slightly to the side to which the tail is carried, exactly as the prow of a boat follows the right and left sweep of the sculler's oar." (see illus. I-C)

Then, continuing with observations on the mackerel, he says,

"The swimming action of the mackerel also shows, to my mind very

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[13] Breder, C. M., Jr., "The Locomotion of Fishes," Zoologica, vol. 4, No. 5, pp. 159-297.
[14] Howell, Op. cit.
[15] Wallace-Dunlop, R. H., "Plate Swimming," Routledge and Sons, London, 1876, pp 87-94.

clearly, that propulsion is effected by passing the blade of the tail across the axis of progression with a rearward reflection of its effective side."

This description may be seen to be very much like the Borelli explanation, meaning that as the tail is flicked backward the rearward side of the tail is effective in pushing the water backward, and consequently by Newton's Third Law, the fish moves forward. A repetition of this action occurs, also propelling, on the return stroke to the initial position. Howell[16], a modern writer, summarizes the features of the action and gives illustrations redrawn from Breder as he accepts the principles brought out by the older writers:

"If we take a fish of the form of a mackerel the swimming motions will be theoretically as follows: the contraction of the muscles of one side will throw the body into a curve, but because of the resistance which the flattened posterior part offers to the water this results in the head being thrown farther to one side than the tail. With the momentum thus acquired by the head and the consequent inertia of the more massive anterior part of the body, the fish is enabled to swing the tail to the opposite side with considerable force. The pressure of the curved tail against the water initiates forward motion and this is maintained by alternations of the movements from side to side."

Crawl Flutter Kick Action is Analogous to the Fishtail Type of Propulsion

Several writers describe the flutter kick as used in the crawl. The best available description is probably that of Mr. L. de B. Handley[17] in which he describes the flutter kick as one in which the legs perform a narrow, alternate, continuous thrash of even scope. It is composed of several more or less wide scissor kicks executed by whipping the legs back and forth with knees almost straight and feet pointed. The features of this action which may be said to be similar to the action of the fishtail are as follows:

(1) There are alternating vibrations or oscillations back and forth across the axis of progression, producing an elliptical movement (trajectory of a single point on the heel of one leg—see Illus. II).

(2) There is a certain flexibility of the knee and ankle joints which is not nearly as good but somewhat similar to the flexibility in the tail of the fish.

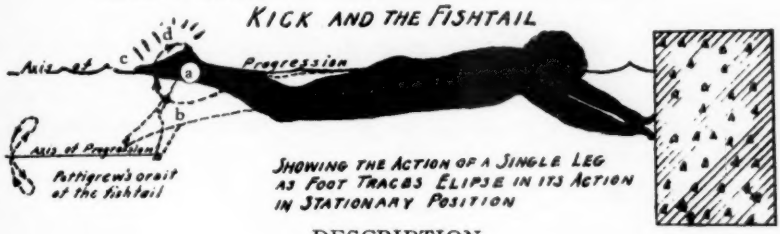
(3) There is a forceful flick of the foot at the start of both the upward and downward movements which drives the water partially backward, just as it is driven backward by the rearward reflection of the effective side in the case of the fish.

(4) There is a marked similarity between the leg action in the flutter kick and the action of the fishtail in that both the movements, left and right

[16] Howell, Op. cit., see pp 16-17.
[17] Handley, L. de B., "Swimming and Watermanship," Macmillan Co., N. Y., 1920, pp. 27-31.

ILLUSTRATION II

ANALOGY BETWEEN THE ACTION OF THE CRAWL FLUTTER KICK AND THE FISHTAIL



DESCRIPTION

An idea of the mechanical action of the Crawl Flutter Kick may be obtained if the orbit of a point, such as the one marked on the heel of the subject, be traced. The initial action in the kick is a dropping of the knee (at x), and even though this be a drop of only 4-6 inches as observation shows it to be, it is sufficient to cause a shortening in the horizontal length of the leg. The point on the heel thus moves across the top of the orbit being pulled in the direction of the shortening, toward the head. The quick downward flip of the foreleg and foot is shown as travelling from d to a to b, cutting across the axis of progression. At b there is a sharp flick of the foot caused by the change of direction from downward to upward and the point traverses the path b to c and is then ready for another cycle. The entire path is an ellipse with both the down-phase and the up-phase propelling. This movement is mechanically similar to the action of the fishtail, the cycle being an ellipse rather than a figure eight.

TRAJECTORY OF A POINT ON THE HEEL OF A SINGLE LEG IN THE CRAWL FLUTTER KICK

DESCRIPTION

As the body moves forward at fast speed a point on the heel of a single leg traces a sinusoidal trajectory as the point moves from a to b to c to d, etc. When the foreleg and foot drive upward, a swirl of water is driven in front of it and follows behind it in the direction approximately as shown by the arrow U; and similarly, on the down drive a swirl of water is driven in front of and follows behind the foot and foreleg approximately in the direction indicated by the arrow D. Both of these arrows according to their direction would drive the water partially backward. The amount of propelling force resulting from the combined action being proportional to the sum of the vectors EU and ED (effective up-kick and effective down-kick, respectively). This is in accordance with Newton's law of motion stating that for every action there is an equal and contrary reaction.

BOTH LEGS TRACE DOUBLE SINUSOIDAL WAVE

in the action of the tail and up and down in the action of the legs, are propelling.

(5) The range of the movement is relatively narrow and performed largely within the path traversed by the body, thus assuring a minimum of resistance by maintaining to some extent the fusiform or streamline shape.

(6) The efficiency of the flutter movement is due partially to the elimination of slip as described by Pettigrew in that swirls are drawn after the feet and by a quick change of direction the foot acts on these swirls. This aids in getting a purchase on the water.

Method of Making Study of Exact Flutter Action

The precise action of the legs as the flutter kick was performed was traced on a sheet as the films from moving pictures were propected frame at a time upon it. A heavy soft pencil was used for the marking. The drawings of foot positions and leg positions given in the illustrations are reproductions drawn to scale of the results obtained. Only the positions were used when the subject was squarely before the camera in order to prevent an error due to perspective. While quite a few quantitative measurements have been taken involving force, time efficiency, and dimensions, the actual measurements taken of a kick in motion were obtained by this method of screen projection and then by application of mathematical proportion, knowing the height of each subject. For instance, if it is known that a subject's height is 74 inches and on the screen the height measured only 23 inches, all linear measurements in the same plane will be in the same proportion as 74:23. One other precaution was used to reduce the possible error. The projection was made as large as practical under the conditions, as it was understood that the percentage error would be smaller in proportion to the increase in size of the dimensions measured.

2. *The "Squeeze Action" as an Explanation of Propulsion*

Statement of the Problem

The "Squeeze Action" theory states that propulsion from the flutter kick results from the action of the two legs acting as a wedge on the V-shaped patch of water enclosed. One writer remarks that it would be impossible for a one legged man to make progress with half a kick[18]. In 1876 Wallace-Dunlop[19] saw that the wedge was not adequate as an explanation for completely explaining propulsion from the leg action in swimming. He remarked that Capt. Webb, who gave the wedge explanation as the entire means of progress in the frog kick, looked at one side of the matter only, inasmuch as the

[18]See Brown, Sterry, "Advanced Swimming," a manual published in the Dept. of Physical Education, University of Illinois, American Review Service Press, Bloomington, Ill., 1925, p. 11.

[19]Wallace-Dunlop, Op. cit. see pp. 28-29.

wedge did not operate in the water with effectiveness owing to the fact that the water was a yielding and fluid substance. The wedge theory has been a matter of discussion for some time among experts and some maintain that it is a very important factor. Some experimentation has been done to determine just what its effect might be in the flutter kick.

Solution of the "Wedge" Explanation by Experimentation

It is a simple matter to show that the wedge action is not essential to progress, or even high efficiency, with the flutter kick. There are three ways in which the wedge may be eliminated and yet have the leg perform the flutter movement:

(1) By using only a single leg in what may be called the *One-Leg Kick.*

(2) By using a kick in which the legs go up and down side by side at the same time. This kick may be called the *Simultaneous Kick* because the legs perform identical movements simultaneously.

(3) By using the legs in the flutter action with the legs spread far enough to eliminate all possibility of the wedge taking place. This kick may be called the *Spread Leg Kick.* Experiments were conducted with each of these kicks by having the subjects swim as fast as possible with each for a length of the tank, 60 feet. The *Stop Watch Method*[20] was used with the proper precautions for starting, stopping, counting leg beats and elimination of fatigue. The subject was asked each time how the kick felt. Practice was allowed on all kicks before the data was collected. All subjects who were tried could make progress with the wedge-eliminated kicks if they could progress efficiently with the normal flutter. The data is presented as collected on five subjects.

Data on the Wedge Eliminated Kicks

The data as presented represents the best of two time trials with the beats recorded which accompanied the fastest trial.

Subject Trials		Normal Kick		One Leg Kick		Simultaneous		Spread Leg	
		Sec.	Beats	Sec.	Beats	Sec.	Beats	Sec.	Beats
1. M. S.	Best	20.0	116	41.0	108	38.6	89	25.0	122
2. G. M. D.	"	30.0	82	40.6	65	33.6	62	36.0	112
3. W. P.	"	20.0	107	31.6	77	30.0	92	25.0	130
4. T. Y.	"	19.0	85	26.0	53	33.2	80	23.0	103
5. T. K. C.	"	14.2	61	21.4	57	21.0	68	16.0	85
Average		20.6	90	32.1	72	31.3	78	25.0	110

Discussion of Results of Testing Wedge Effect

The results show that good progression can be made with only one leg acting in the flutter kick. The efficiency of the One Leg Flutter Kick is greater than one would expect. The average efficiency for the subjects above is 62.3%. It is demonstrated that a single leg can work more efficiently flutter fashion than it can work in coopera-

[20]See Beach and Pool Mag., Feb., 1930, pp. 15-19 and 32-34, for complete description of procedure (by the writer).

tion with the other leg*. This should clear the point that two legs are not necessary in this type of action any more than it is necessary for all fish to have two tails. The efficiency with the Simultaneous Flutter Kick was 65.8% and with the Spread Leg Flutter Kick 82.5%. If both legs could be worked with the same efficiency as one alone was worked with these five subjects, not only would there be no loss because of the absence of the squeeze action, but there would be a gain in speed efficiency totaling 22.3%. The Simultaneous Kick shows a loss of 34.2%. This was expected because the balance was upset greatly in this kick. The subjects complained that it seemed impossible to drive the legs much below the surface, consequently, the up-kick phase was practically eliminated, progress being made by flapping the feet downward in fast narrow movements against the surface. This method is sometimes used in swimming with the hands tied behind the back and the feet tied together, although faster progress can be made if the whole body is moved up and down in a wave-like action. The loss in efficiency may be attributed to disturbance of the balance and poorer control, as evidenced by fewer beats, rather than to the absence of the wedge effect. It is clear, however, that much better stability results when there is a balanced action of one leg going down and the other coming up simultaneously. The result is a counter-balancing effect with the body remaining on an even keel. The Spread Leg Kick shows a loss of 18.5% as compared with the normal kick. This loss may be attributed to some extent to the increased resistance caused by the legs being in this spread position and also partially to the awkwardness of the movement.

Conclusion on the Efficiency of the Wedge Action for Propulsion

The explanation of propulsion as given by the so called "wedge" action is entirely inadequate. A wedge of two legs is not necessary nor is there justifiable evidence that wedge effect increases the efficiency of propulsion. The mechanical reasons for propulsion are not explained satisfactorily by the wedge but instead by the fishtail theory previously presented. This theory is based soundly upon the laws of mechanics.

3. *The Relative Value of the Up and Down Phases of the Kick*

Statement of the Problem.

One of the debated problems is whether the up-kick movement of the flutter kick helps to propel as well as the down-kick phase. The theories of the fishtail action indicate decidedly that both movements are propelling. In fact, this characteristic is one of the important

*Note: One finger may even work with more efficiency than two at once, on opposite hands, doing different movements.

reasons why the fishtail is so efficient. It is certain that some instructors have thought of the up-kick as a recovery movement with no propulsive component of force.

Solution of the Value of the Up-kick by Experimentation

The evidence for the solution of this problem has come from four principal sources:

(1) Feeling the Power Impulses from the Feet. (See Illus. III)
(2) Group Observation of the Normal Kick.
(3) Study of the Peculiar Kicks which Eliminate the Up-kick Swirls.
(4) Moving Picture Study of the Normal Kick.

Feeling the Power Impulses from the Feet

The subjects were asked one at a time to get into the pool and kick a crawl flutter kick while holding on to the gutter. Two experimenters were assigned to each subject to feel the swirls, one on each side feeling the swirls from a single leg. Each experimenter stood near the feet and to one side facing the legs. One hand was placed below the kick to feel the swirls going down and the other placed just behind the foot at the surface to feel the swirls coming up. The swirls are rather easily located. The swirls felt as if they were coming almost entirely from the foot itself; little effect was detected as coming from the shin or calf of the leg. On each down-kick and up-kick of the foot a powerful swirl was felt. After considerable practice in feeling the swirls it was decided to estimate the angle which the swirls made with the vertical. (See Illus. III).* In addition an attempt was made to determine which set of swirls was stronger, those going down or those coming up.

Data Collected by Feeling Swirls from the Feet

In the data presented below two observers felt the kick according to the method just described and agreed on the angle and relative strength before reporting their observation.

Subject	Angle of down-kick Swirls with vertical	Angle of up-kick Swirls with vertical	Stronger
1. S	15 degrees	45 degrees	up-kick
2. T. K. C.	15 degrees	40 degrees	up-kick
3. M.	40 degrees	60 degrees	same
4. P.	15 degrees	45 degrees	down-kick
5. M. S.	40 degrees	55 degrees	down-kick
6. K.	15 degrees	45 degrees	down-kick
7. T. Y.	45 degrees	60 degrees	up-kick
Average	26.4 degrees	50 degrees	Conflicting
	Range 15-40 degrees	Range 40-60 degrees	
	Up-kick stronger	3	
	Down-kick stronger	3	
	No difference	1	

*The use of two sticks hinged together at one end and having considerable friction in the hinge to prevent slipping is an aid in estimating the angle. One operator may adjust the angle-sticks, the other locating the swirls. After the sticks are opened to fit the angle, they may be laid upon a protractor and the angle read.

It was also observed that:

(1) With the *Legs Low in the Water* the effectiveness of the down-kick swirls was destroyed because the swirls were then directed straight downward toward the bottom and not backward so as to produce propulsion. However, the up-kick swirls were then directed more backward than ever and became apparently more effective for propulsion.

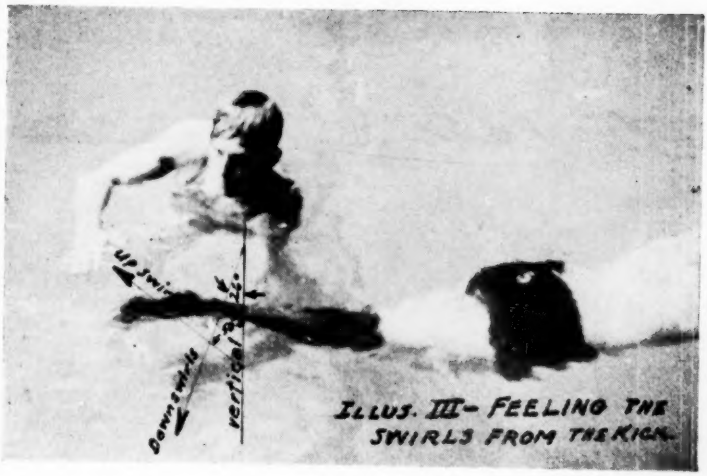
(2) *With the Legs Kicking so That the Feet Just Broke the Surface,* as in the normal kick, both swirls seemed to be directed partially backward so as to be effective for propulsion. The data presented below was compiled when the legs were kicking in this position.

(3) *With the Legs Bending at the Knee and Lifting the Feet 75-90 Degrees Out of the Water* it was noticed that the kick took on the flapping effect characterized by the feet flapping downward on the surface but not going much below it. The down-kick swirls could be detected but the up-kick swirls seemed eliminated.

Summary of Feeling the Swirls from the Feet

An average result of feeling the swirls from seven subjects gave 26.4 degrees for the angle which the down-kick swirls made with the vertical and 50.0 degrees for the up-kick. It was evident that the up-kick swirls were better directed for effective propulsion in the majority of cases tested. This seemed particularly so in the subjects with most efficient kicks. A graphical analysis constructed from these results gives some interesting results. (See Illus. IV) The kick is shown with vectors representing the magnitude of the forces coming from the feet. In the graphical solution shown just above the feet, the up-kick vector and the down-kick vector are assumed to be equal in magnitude according to the average result of the evidence.[21] These vectors are shown as the hypotenuses of two triangles, TFU representing the total force of the up-kick swirls and TFD representing the total force of the down-kick swirls. The effectiveness for producing propulsion of these two equal vectors is considerably different, with, however, the up-kick action greatly favored. This is due to the anatomical construction of the foot. The graphical solution shows the up-kick produces an effective component EU equal to 63.0% of the total effective power for forward propulsion; and the down-kick 37.0%. A case is assumed of a swimmer with a kick developing 16 pounds horizontal propulsive force for the computation. This value is one obtained for a good kick by testing with the kick-meter to be described later. One effect of the flutter kick is that of causing the feet to rise to the surface. This indicates that the vertical component of force supporting the feet is greater on the down-kick than on the up-kick. This is an important point because it enables the crawl

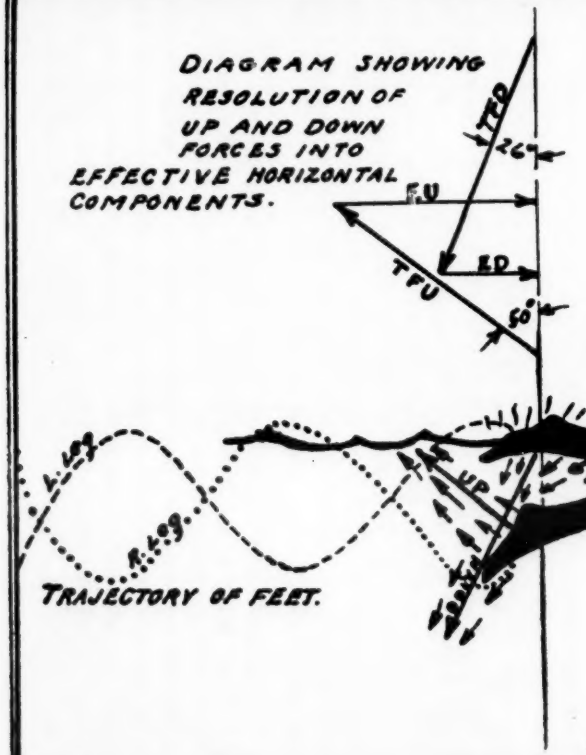
[21]Note that this conclusion agrees with Howell regarding his assumption of equal forces on up and down or side to side movements for efficient kick. Op. cit.



ILLUS. III– FEELING THE SWIRLS FROM THE KICK.

ILLUSTRATION IV

RELATIVE VALUE OF UP AND DOWN PHASES OF THE CRAWL FLUTTER KICK.



Let hypotenuse TFD = TFU = 1

Effective UP-KICK = EU = sin 50° x 1 = .766

Effective Down-KICK = ED = sin 26° x 1 = .438

but as tested ED + EU = 16 lbs. (in one case)

and ED and EU are proportional to the sines of the opposite angles.

$\therefore \frac{ED}{EU} = \frac{\sin 26°}{\sin 50°}$

or .766 ED − .438 EU = 0

therefore, solving the simultaneous equations

$$\begin{cases} ED + EU = 16 \text{ lbs. (in this case)} \\ .766\,ED - .438\,EU = 0 \end{cases}$$

ED = 5.8 lbs. = 37.0 % of effective power

EU = 10.2 lbs. = 63.0 % " " "

ED + EU = 16.0 lbs. = 100.0 %

T.K.C.

swimmer to maintain a position practically parallel to the surface of the water. Illus. IV shows that the vertical component of TFD is approximately 57% longer than the vertical component of TFU. The writer awaits with interest the data of other experimenters to see if they will confirm these results.

Group Observation of the Normal Kick

Each observer was given a piece of paper with a few definite questions about the flutter kick which were to be answered after careful observation. The observation was recorded without conference with other observers. A person who had a very efficient kick, was asked to be the subject. He was instructed to kick the flutter board the length of the pool several times at slow, medium and fast speeds alternately until all observers had come to a decision on each point. There was no hurry about recording observations. The observers were instructed not to put down anything unless they were sure that it was right. In this experiment 14 experienced observers reported that:

(1) The up-kick phase of the movement was seemingly as powerful and as quickly made as the down-kick phase.

(2) All stated that the sole of the foot at the start of the up-kick was in a better position to push the water backward than the instep was at the start of the down-kick.

The Study of Peculiar Kicks Which Eliminate The Up-Kick Swirls

Three Odd Styles of Kicks Which Eliminate the Up-kick Swirls

The study of three odd styles of flutter kicks, which are alike in that they all eliminate the powerful up-kick swirls, gives additional evidence. The study was conducted by the speed efficiency method using the stop watch method. The objective was to compare the normal kick with each of the odd kicks in speed efficiency and then draw conclusions. It would be expected that in each of these kicks the speed would be decreased considerably according to the characteristics of the kick. First, the odd kicks will be briefly described and their peculiarity pointed out:

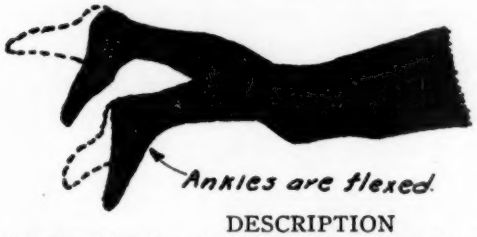
(1) *The Simultaneous Kick* has already been mentioned. It is executed by both feet going up and coming down at the same time. The subjects reported that it was impossible to drive the legs under the surface very much and that the best effect was obtained by flapping the feet downward against the surface in fast, narrow movements. The practical effect was to eliminate the greatest part of the powerful up-kick, because the feet did not go under deep enough to get a purchase on the water. If they did go under, then the entire body balance was destroyed trying to get them up again.

(2) *The Flapping Kick* is executed as a normal flutter except that the legs are bent at the knee considerably, the foot is lifted from the water and in turn is flapped forcefully downward against the surface of the water. The emphasis in the kick ends here, however, the feet not being allowed to drive under the water very much. The practical effect is very similar to the kick above, namely, that the up-kick swirls are eliminated.

(3) *The Hooked Foot Kick* is executed by holding the foot in a hooked position (see Illus. V). This means that the foot is flexed and is held in a position just opposite to that in which the toes are pointed. This position eliminates the up-kick swirls and also changes the direction of the down-kick swirls so that the swirls become directed downward against the bottom of the pool.

ILLUSTRATION V

THE HOOKED FOOT KICK.



DESCRIPTION

All propulsive force is eliminated by holding the ankles as shown in the diagram. The feet move up and down with the toes hooked.

Data Collected on the Peculiar Kicks

The data presented represents the best of two time trials in each case. The peculiar kicks are compared with the normal type.

Subject	Normal Kick Sec.	Normal Kick Beats	Simultaneous Sec.	Simultaneous Beats	Flapping Sec.	Flapping Beats	Hooked Foot Sec.	Hooked Foot Beats
1. T. C.	14.2	61	21.0	68	21.8	86	Only slightly	
2. T. Y.	19.0	85	33.2	80	35.4	115	Only slightly	
3. W. P.	20.0	107	30.0	92	25.8	100	Only slightly	
4. G. D.	30.0	82	33.6	62	31.8	82	No movement	
5. M. S.	20.0	116	38.6	89	Fatigued stopped		No movement	
Average	20.6	90	31.3	78	28.7	96	Practically no motion	

Summary of the Study of Peculiar Kicks

The *Simultaneous Kick* showed a loss in speed efficiency of 51.9% as compared with the normal kick; the *Flapping Kick* gave a loss of 39.3%; and the *Hooked Foot Kick* caused a loss of practically 100% in speed. From these results it would seem that the up-kick phase of the kick was worth more for propulsion than the down-kick. The average loss caused by eliminating it in the three kicks above equals 63.7%. This agrees favorably with the result obtained by feeling the angles, namely, 63.0%.

Moving Picture Study of the Normal Kick

The careful study of moving pictures made of subjects swimming in the Springfield College pool and also of the swimming of Johnny Weismuller and Martha Norelius as exhibited in the Grantland Rice Sportlight Film, "Crystal Champions", removes all doubt that the up-kick phase of the kick is capable of powerful propulsion. Illus. V shows the play of the ankle in the kick. There is a quick snap of the foot as it changes from a position of flexion in the ankle to extension. This occurs at the start of the up-kick. The sole of the foot pushes the water vigorously backward. This was determined by turning the movie film frame and noting the action of the ankle and foot. The sole of the foot is undoubtedly employed with force and is in a better position mechanically to push the water backward than the instep is on the down-kick.

Conclusion on the Relative Value of the Down-kick and Up-kick

The evidence points in a very conclusive way to definite propulsion resulting from the up-kick action in the crawl flutter kick. Four kinds of evidence have been considered and in each case it was evident that propulsion resulted. The point of difficulty would seem to be the exact evaluation of the forces. This, of course, is a very difficult problem. A conservative statement would say that the up-kick is certainly as valuable, if not more so, for propulsion than the down-kick, although the evidence given indicates that it is *more* effective. One case, encountered while studying the muscular force possible in the movements of the down-kick and up-kick, was that of a varsity swimmer who had a very poor kick as compared with the other members of the squad. While attempting to find out just why his kick was poor, it was found that his extensor muscles of the hip were much weaker than those of any of the other swimmers. Observation seemed to confirm the fact that his legs did not lift up with that quick snap which is a characteristic of a good kick. This difficulty with the up-kick caused the inefficiency.

4. *The Relative Value of Ankle, Knee and Hip Actions*

Statement of the Problem

Frequent discussions have arisen among coaches and swimmers as to the value of flexible ankles in the flutter kick, the amount of knee bend to be allowed, and the value of controlling the movement from the body proper. Some coaches instruct their pupils to keep their legs straight and their toes pointed, while others allow considerable knee bend. It has already been remarked that Sundstrom in his swordfish stroke attributed his speed to flexible ankles. Kistler,

in replying to the questionnaire on the Symposium of the Crawl Stroke, stated that the kick as used in Australia was known to have more knee action than that finally adopted by American swimmers. Kiphuth, at Yale, believes in control from the mid-section of the body; and the swimming gymnastics which he gives there are mostly devoted to conditioning the back and abdominal regions because of the demands which the kick makes upon them. With the development of the Stop Watch Method, a method of checking up upon the theories thus far advanced became available.

Solution by Immobilization Tests

It would seem reasonable that if the ankles were immobilized by strapping with a board and ankle bandage as shown in Illus. VI, the full play of the ankle would be stopped. The effect expected might be somewhat similar to that which would be expected if a small board were so strapped to the tail of a fish. The fish depends largely upon the flexibility of its tail for efficiency in swimming. Furthermore, a still greater loss in speed would be expected if the knee joint were strapped in addition. Illus. VII shows the method of strapping the knees alone. Illus. VIII shows two views with both the ankles and knees strapped. The legs would then be controlled entirely from the hips, just as straight rods. This kind of control is referred to as "Hip Control" or "Hip Action". Any loss in speed might be referred to the normal kick for a comparison in terms of percentage. In this manner, considerable experimentation has been done with various combinations of strapping. It was found that it was impossible to immobilize the joints completely, particularly the knees, because the flesh gave somewhat to the pressure of the boards. The results of adding the various percentages obtained independently from the ankles, knees and hips usually gave a total slightly more than 100% The extra percentage has been assumed to be due to this leakage.

A sample case will be taken in which the computations will be explained in detail and then the results on several subjects will be given. The following data were obtained on the subject Nelson:

Test	Observations Sec. Beats	Remarks
Normal Kick	27.6 - 103	Relatively poor kick
With Ankles Strapped	30.4 - 117	
With Knees Strapped	1:25.8 - 250	
With Knees and Ankles Strapped	2:14.4 - 316	

Computations:

(1) *To Determine Percent of Speed Due to Ankle Action*

$$\frac{\text{Time Normal Kick}}{\text{Time Ankles Strapped}} \times 100 = \frac{27.6}{30.4} \times 100 = 91.0\%$$

This means that the time required to kick 60 feet with the ankles strapped was 91.0 per cent as fast as that required to kick 60 feet with the normal kick.

Hence, Loss Due to Strapping Ankles=100%—91.0%=9.0%

(2) *To Determine Percent of Power Due to Knee Action*

$$\frac{\text{Time Normal Kick}}{\text{Time Knees Strapped}} \times 100 = \frac{27.6}{85.8} \times 100 = 32.2\%$$

This means that the time required to kick 60 feet with the knees strapped was only 32.2 percent as fast as the time required to kick 60 feet with the normal kick.

Hence, Loss Due to Strapping Knees=100.0%—32.2%=67.8%

(3) *To Determine Percent of Power Due to Hip Action*

$$\frac{\text{Time of Normal Kick}}{\text{Time Knees and Ankles Strapped}} \times 100 = \frac{27.6}{134.4} \times 100 = 20.5\%$$

This means that the time required to kick 60 feet with both knees and ankles strapped was only 20.5 percent as fast as the time required to kick 60 feet with the normal kick. This represents what the hip action accounted for directly.

Hence, Percent of Power Due to Hip Action=20.5%.

(4) The total power would be represented, of course, by 100%. Also, this should equal the sum of the percentages obtained for the ankles, knees and hips.

Hence, in this case, Ankles gave	9.0%
Knees gave	67.8%
Hips gave	20.5%
	97.3%

Data of Flutter Kick Analyses

The following presents data taken on eight subjects. It is important in analyzing the characteristics of efficient kicks as well as poor ones.

Subject	Normal Kick Sec. Beats	Ankles Strapped Sec. Beats	Knees Strapped Sec. Beats	Both Strapped Sec. Beats
*Ford	16.8 - 86	23.2 - 90	21.6 - 90	29.0 - 100
*T. K. C.	16.6 - 78	19.5 - 91	26.6 - 150	29.0 - 120
Littlefield	19.0 - 84	24.4 - 108	28.4 - 126	35.8 - 144
*Zweidinger	16.0 - 80	23:0 - 100	26.8 - 110	44.6 - 140
Nelson	27.6 - 103	30.4 - 117	1:25.8 - 250	2:14.4 - 316
V. R.	26.8 - 132	57.2 - 217	60.0 - 163	x-35′ - 200 plus
S.	28.0 - 130	31.2 - 142	x-30′ - 160 plus	x-30′ - 116 plus
G.	23.4 - 72	34.4 - 150	49.6 - 184	x-30′ - 180 plus

Results of Kick Analysis Computations

Subject	Remarks	Computed Percentages Ankles	Knees	Hips	Total
*Ford	Excellent sprinter	27.5%	22.2%	58.0%	107.5%
*T. K. C.	Excellent sprinter	14.7	36.3	57.2	108.2
Littlefield	440 man (5:40)	22.2	33.2	53.0	108.4
*Zweidinger	Excellent sprinter	30.5	40.3	35.9	106.7
Nelson	440 man (5:40)—poor kick	9.0	67.8	20.5	97.3
V. R.	Poor swimmer—poor kick	53.2	55.3		108.5
S	Poor swimmer—poor kick	10.2	89.8		100.0
G.	Poor swimmer—poor kick	32.0	52.8		84.8

*Represents three swimmers with exceptionally good kicks.

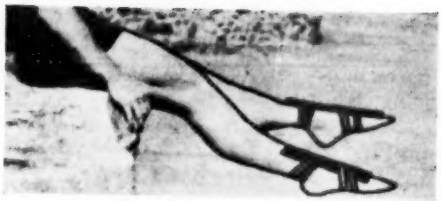


ILLUSTRATION VI

Method of Immobilization of Ankles

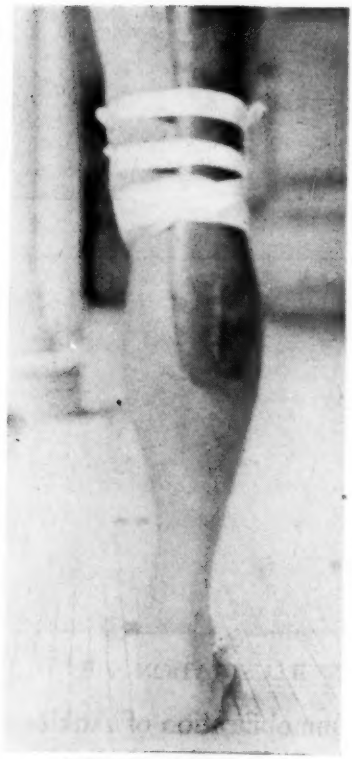
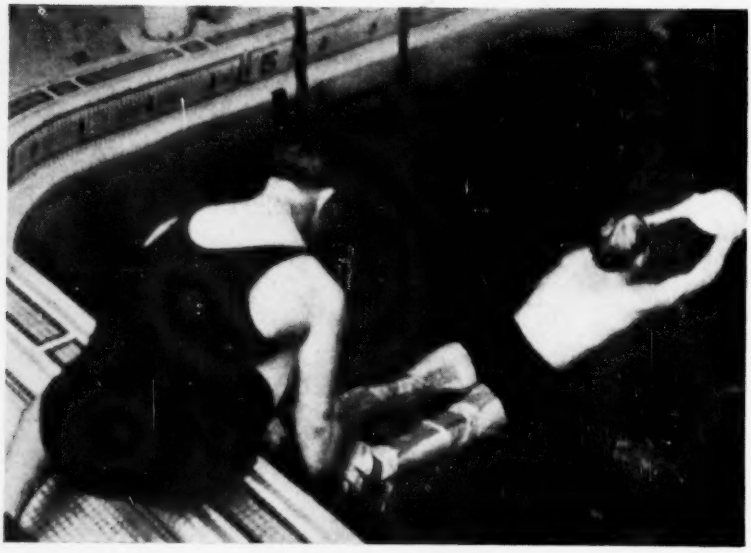


ILLUSTRATION VII

Method of Immobilization of Knees



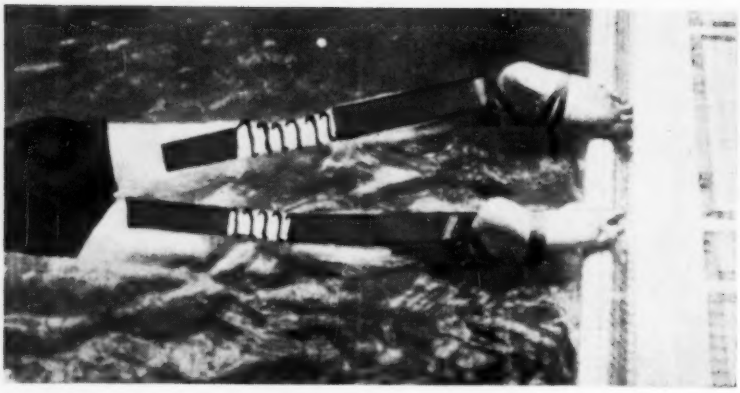


ILLUSTRATION VIII

Method of Immobilization of Ankles and Knees

Summary of the Relative Value of the Ankle, Knee and Hip Actions

There is definite evidence here to show that the swimmers with the best flutter kicks get a much greater percentage of power from the hips. The greatest fault which the poor swimmers have in regard to the leg kick is the lack of power in the hip drive. Four good sprinters of varsity caliber averaged 51% of the total power from the hips, with three of the subjects well above 50%. On the other hand, four swimmers with relatively poor kicks showed an outstanding lack of ability in this same characteristic. The best of these developed only 20.5% speed due to the hips and the other three could not progress at all when depending upon the hip action alone. This points rather decidedly to the fact that for efficient propulsion a great deal of the control should come from the body proper, the abdominal and particularly the lower back regions being governed by the muscle groups which flex and extend the leg upon the pelvis. In swimmers using a powerful kick properly, it has been noticed that the buttocks will ride unusually high, even coming above the surface of the water. This is due to the flexion of the thigh upon the pelvis and is a sure sign that the power to a great extent is coming from the abdominal section. Swimmers with poor kicks do not seem to do this but rather localize the kick in the knees and ankles. The first four varsity swimmers averaged 33.0% speed due to the knee action. The swimmers with poor kicks averaged 66.4% indicating marked localization in the knees. In other words, with a lack of proper hip control the propulsion must come from the ankle and knee action. It is, however, the most inefficient type. The ankles give rather a varied but fairly uniform result among the varsity swimmers with good kicks. These averaged 23.9% speed due to ankle action with a range of 14.7-30.5%. The poor swimmers show a great variation, perhaps due to improper ankle action as well as a greater localization of power in the ankles due to its lack from the hips. The ankles will be discussed in detail showing how they may be the principal regulators of the power applied for propulsion.

The Amount of Propulsive Force Developed by the Kick

The Problem

It is desirable to know the amount of propulsive force developed by the kick for several reasons:

(1) To compare the Propulsive Force of the Flutter Kick with Other Types of Kicks.

(2) To Show the Significance of the Weight of the Feet in Body Position Computations.

(3) To Compare Swimmers with Each Other.

(4) To Use in Computations of Effective Work Done by the Flutter Kick, Including the Efficiency of the Kick.

Design of the Kickmeter

The design of the kickmeter as shown in the Illus. IX is simple enough so that any one may easily construct it. It is based upon the law of leverage in physics that the weight or force times its lever arm is equal to the scale reading times its lever arm. In this case the fulcrum is shown at 0. Therefore, $F' \times 7'' = F \times 25''$. By the use of this principle of leverage a more accurate reading can be secured. The objection to the use of any instrument of this kind employing spring scales is the fluctuation of the pointer which makes it exceedingly hard to get an accurate reading. The design of the kickmeter partially eliminates this difficulty in the following manner. The distance from 0 to S is relatively short as compared with the distance 0 to F. This reduces the movement actually transmitted to the scale pointer making it easier to read. The force recorded, however, is magnified by the ratio of the lever arm and this is also helpful in getting the full swing of the pointer away from zero.

Precautions for Use of Kickmeter

It is important that the meter, if built to the dimensions shown, be adjusted to the proper height above the water. The water should intersect the vertical push-plank just as illustrated. If too much of the end is allowed to go beneath the water, inaccuracies will occur due to the buoyancy of the plank itself. When reading the pointer, *maximum and minimum readings must be taken and the average of these used.* It has also been found that to push with the head gave a more accurate reading for most subjects. In this case a pad should be placed on the end of the push-plank to protect the head. Several trials should be taken and the results averaged.

Arrangement of Data in a Sample Case

The data for each case tested may be arranged as follows:

Subject: C Type of Kick: Flutter

Trial	Maximum	Minimum	Average	How Pushed
1	72	36	54	With the Head
2	88	30	59	With the Head
3	78	26	52	With the Hands
4	81	28	54.5	With the Hands
5	73	36	54.5	With the Head
General Average			54.8 lbs.	

Then, making the correction for leverage,
$F' \times 7''$ equals $F \times 25''$
54.8×7 equals $F \times 25$

$$F \text{ equals } \frac{54.8 \times 7}{25} \text{ equals } 15.38 \text{ lbs. force.}$$

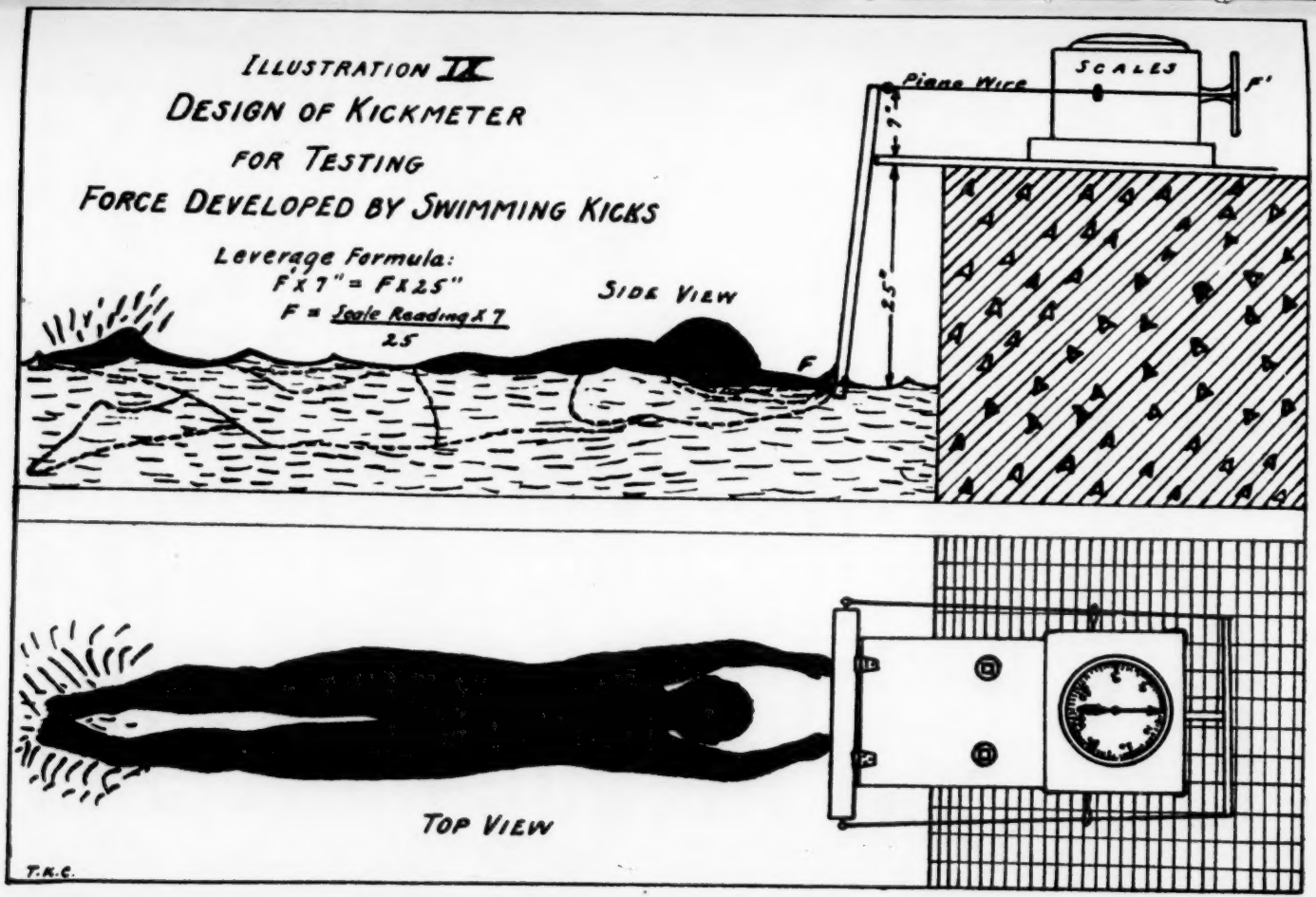


ILLUSTRATION IX
DESIGN OF KICKMETER
FOR TESTING
FORCE DEVELOPED BY SWIMMING KICKS
Leverage Formula:
F x 7" = F x 25"
F = Scale Reading x 7 / 25
SIDE VIEW
Piano Wire
SCALES
F'
7"
25"
F
TOP VIEW
T.K.C.

Comparison of Crawl, Back and Breast Kicks

The following results were secured upon comparing the kicks of several swimmers:

Subject	Crawl (Dis. 60′) Sec.	Flutter Lbs.	Back Flutter Lbs.	Breast (frog) Lbs.
Nel	27.6	7.5	10.5	19
Wel	21.3	12.8	11.9	25.6
Zwei	16.0	15.25	16.8	21.0
To	16.6	15.38	14.0	27.9
	Average	12.73	13.3	23.4

From this it may be seen that the breaststroke frog kick gives a greater force. This is practically known to be so as a good frog kicker can drive a good flutter kicker backward when kicking against each other on opposite ends of a flutter board. The crawl and back crawl kicks are about equal in propulsive force.

Computation of Work Done in Flutter Kick

An approximate value may be obtained of the work done in the flutter kick with the knowledge of the kick now available.

Data: Width of Kick—18 inches or 1.5 feet.
Horizontal Force—12.73 lbs.
Beats in 60 feet—70.
Angle of Swirls—up, 50 degrees; down, 26 degrees

Referring to Illus. III, facing page 100.

$$\text{Total Force on Up-Kick (TFU)} = \frac{EU}{\sin 50 \text{ degrees}} = 13.0 \text{ lbs.}$$

$$\text{Total Force on Down-Kick (TFD)} = \frac{ED}{\sin 26 \text{ degrees}} = 13.0 \text{ lbs.}$$

Sum Total of Force=26 lbs. per leg per cycle.
Distance Through Which Force Acts= Width$\times$2=1.5′$\times$2= 3.0′ per leg per cycle.

In a length of the tank, 60 feet, there would be 35 cycles per leg or one-half the number of beats.

Therefore, total distance in 60 feet that the force acts is 3 feet$\times$35 cycles= 105 feet.

Work done per leg=Force$\times$Distance=26$\times$105=2730 ft. lbs.
Total work done in 60 feet=2730$\times$2=5460 ft. lbs.

Power Developed in Flutter Kick

Since power developed is equivalent to work done per unit of time, and there are 550 ft. lbs. of work per second in each horsepower,

$$\text{H. P.} = \frac{5460}{14.8 \times 550} = .671$$

Propulsive Efficiency of the Flutter Kick

Referring to Illus. III again, it may be seen that the effective power for propulsion is to the total power as the horizontal components of the forces are to the hypotenuses of the force triangles, or

$$\text{Effective Power} = \frac{16}{26} \times .671 = .413 \text{ Horsepower}$$

$$\text{Efficiency} = \frac{\text{Effective Work}}{\text{Total Work}} \times 100 = \frac{.413}{.671} \times 100 = 61.6\%$$

This conclusion is interesting because it indicates that 48.4% of the total work done in the flutter kick is useless for propulsion, although a part of it serves a purpose by helping to keep the legs horizontal to the surface.

Regulation for Maximum Efficiency

1. *The Ankle as a Means of Regulating the Kick*

In spite of the source of power coming principally from the hip and knee action, *the ankle may regulate this power* completely. Maximum efficiency in the kick is obtained when the ankles are loose, free to move with the currents of water about them. In this situation the ankles may be thought of as double-acting hinge joints moving up and down with the legs. This is literally true except at one instant in the kick cycle. *On the up-kick there is sharp extension of the foot at the ankle joint and the sole of the foot pushes the water forcefully backward.* This is the most peculiar and believed to be the most difficult part of the act to learn. By glancing at Illus. V it may be seen that the left leg is shown at the end of the down-kick. At this point the foot makes a quick flick, going to a flexed position at the ankle as shown, and *then at the start of the up-kick sharply extends.* In Weismuller's kick as measured on the screen, the flexion and extension at this point in the moving kick at fast speed goes through an arc of approximately 90 degrees. The mechanical effect of this may be shown to be very significant for effective propulsion. *As the foot drives downward on the down-kick, it draws after it a current of water; and owing to the sudden change of direction or "flick" of the foot at the end of the down-kick, the bottom of the foot is caused to act against these swirls on the way up.* This is the same effect which Pettigrew said reduced the slip in the fishtail action. It is a most important point to be emphasized in the mechanics of the flutter action. It indicates why the kick is more efficient at high speeds than at low speeds. For the flutter kick to be effective it must act fast enough to intercept these swirls. A similar effect occurs at the top

of the cycle but it is not believed to be as great, owing to the fact that a part of the foot is lifted from the water; and the bend in the knee, if allowed very much, delays the beat downward so that the swirls are lost to a great extent.

Timing of a Single Cycle

By counting the frames as photographed by the moving picture camera the following time relations occur in Weismuller's kick during fast swimming:

Phase of Kick	Number of Frames
At Top of Cycle	0
*Fast Propulsive Drive	1
To Cross Horizontal	3
To Bottom of Down-kick	9
Total for Down-kick	13

Check on time of entire cycle 26 frames

At Bottom of Cycle	0
Relaxation of Ankle	3
*Fast Propulsive Drive	1
To Cross Horizontal	3
To Top of Up-kick	3
Change Direction at Top	3
	13

These time relationships show that there is a distinct point of emphasis on both the down-kick and up-kick when the kick is driven faster. These two points are located at the phases of the kick when the legs are most advantageously placed for propulsion; namely, (1) just after the legs start downward, (2) just after the legs start upward. Attention is called to the distinct period of relaxation at the end of the down-kick or start of the up-kick.

Measurements of Ankle Flexibility Correlated with Speed

The fact that the ankle is caused to flex at the end of the down-kick and then sharply extend during the propulsive drive in the up-kick would seem to indicate that ankle flexibility is a most important characteristic for an efficient kick. This is known to be a fact. In the table previously given showing the percentage of speed derived from the ankles, knees and hips, the ankle flexibilities are known for the five varsity swimmers. The correlation of ankle flexibility with speed is indicated in the table below:

Subject	Degrees Ankle Flexibility	Time 60'	% Speed
Zweidinger	90	16.0	30.5
Ford	89	16.8	27.5
Littlefield	74	19.0	22.2
T. K. C.	70	16.6	14.7
Nelson	69	27.6	9.0

In these five subjects the per cent of speed resulting from the ankle action is directly proportional to the flexibility possible in the ankle joint. However, by unusual strength and control from the pelvic region a swimmer may have a very efficient kick in spite of only fair ankle flexibility. Lack of flexibility in the ankles may be due

to shortened Gastrocnemius and Soleus muscles in the calf or shortened Tibialis Anticus in the front of the leg. It has also been determined that in a sample group of swimmers measured at the Red Cross Training Institute, Brimfield, Mass., the expert swimmers with good kicks had better ankle flexibility than a comparative group of poorer swimmers:

Experts		Average Swimmers	
Degrees	Speed 60′	Degrees	Speed 60′
76.9	18.4	58.0	27.3
96.0	22.4	54.0	23.0
76.0	20.0	67.5	29.0
76.0	25.8	66.0	30.0
87.0	18.4	52.5	22.6
90.0	19.0	75.0	26.2
89.0	16.8	56.0	37.4
65.0	17.8	63.0	19.0
		64.0	20.0
		70.0	21.5
Average 81.9	19.8	Average 62.6	25.6

In these figures it is reflected that the expert swimmers with better kicks have greater flexibility in the ankles than the average swimmers with poorer kicks. A 23.6% superiority in ankle flexibility corresponds to a speed advantage of 29.3%. It is obvious that it should be helpful to stretch the ankles in special training exercises. Also, the kind of exercises which greatly harden the lower leg muscles should be avoided, such as running or jumping on pavements or hard floors.

Reversed Direction May be Obtained With Hooked Foot Kick

It has already been mentioned that 100% speed may be lost by hooking the toes. It was also discovered that a reversed direction is possible. The method of executing this kick is to keep the toes hooked and while kicking flutter kicks avoid breaking the surface of the water very much with the heels. In other words, keep the legs low in the water. This action is called the "Reversed Flutter." The explanation of the phenomenon is that the up-kick swirls are entirely eliminated and the down-kick swirls actually direct the water currents under the body so as to propel the water forward and the body backward. Illus. XI shows how the water currents may be directed this way when the leg is too low in the water. This is an important point in teaching because it is frequently the fault in beginners. In order to overcome this instructors should tell beginners to point their toes. However, such instruction is only over-correction for the time being because a swimmer with a good flutter kick does not kick with the toes rigidly pointed. Such a method leads to tightness of the leg muscles and early fatigue. Cramps in the calf are caused by this. Much drill should be given in loose ankle movements, such as flicking the ankles up and down while sitting on the edge of the pool or a chair. It is the belief of the writer that the sensory surfaces of the foot must

become educated to the pressure of the water before the finely adjusted control can be established, which, as a reflex, enables alternate relaxation and forceful pressure to occur as swiftly as required in the skillful kick. It is known that the surface of the foot is very sensitive to pressure.[22] Just how long this sensory education takes is unknown and it would undoubtedly vary in different people. In addition to leg exercises for the extensor action in the back, much practice should be given for this ankle action.

The Theory of Toeing in for Better Efficiency

Numerous writers have stated that "toeing in" produced a more efficient kick. Some experiments were tried along this line with the stop watch method but with inconclusive results. This is due to the fact that some people are naturally more pigeon toed than others. It was found that any attempt to hold the feet in an unnatural position caused a loss of efficiency. It may be noticed by shaking the ankle in a natural, loose manner that it oscillates slightly from a position of toe-in as the toes are pointed to a position straight with the leg as the foot is flexed at the ankle. This rotation, coupled with the fact that the body is rolling also from side to side during the stroke, accounts for the appearance of the feet being toed-in quite noticeably at the top of the down-kick. However, to coach that the toes should be held in this position arbitrarily throughout the kick is wrong because the natural position will produce the best flexibility in each individual.

It is flexibility which is very important—as has been demonstrated; also, the propelling surface is not changed by toeing-in. It may be thought that by toeing-in, the swirls from the feet will drive against each other as one foot starts up and the other down and better traction results because of increased density of the water. This may occur to some slight extent but the evidence is not very favorable to its effectiveness in increasing the efficiency as shown in the study of the "squeeze action". This brings out the point that the legs really kick in an arc as they travel up and down.

2. *The Amount of Knee Action*

The Problem

While analyzing the kicks of several swimmers it was found that those who derived the most of their speed from the knee action went slower than those who concentrated upon a hip action. The amount that the knees should bend has always been in dispute. Of course,

[22] Kellogg, J. H., "Rational Hydrotherapy," Phila., 1901, p. 117, discusses muscular reflex areas, particularly the plantar region. Howell, W. H., "Textbook of Physiology," Phila., 1920, 7th ed., p. 158, refers to the "extensor thrust" as described by Sherrington in the "Integrative Action of the Nervous System."

progress can be made with a slight bend or a much greater bend and it is a matter of relative efficiency which is to be determined.

Solution by Experiments

The Stop Watch Method was applied to this problem. Data was collected upon a group of swimmers by having them try out various degrees of bend for a length of the tank and time each trial. The results were as follows:

Data Represents the Best of Two Efforts

Subject	90 Degrees Sec. Beats	45 Degrees Sec. Beats	15 Degrees Sec. Beats	0 Degrees Sec. Beats	
A	29.0 - 112	27.0 - 123	*20.5 - 95	*20.5 - 114	tie
G. D.	34.7 - 101	24.6 - 80	*23.7 - 89	27.6 - 117	
W. P.	29.8 - 125	23.3 - 100	*22.8 - 113	25.9 - 108	
T. Y.	35.8 - 110	39.0 - 104	29.5 - 108	*19.5 - 101	
T. K. C.	31.6 - 105	17.8 - 77	*17.0 - 89	17.4 - 97	
Average	32.1 - 111	26.3 - 97	22.7 - 99	22.1 - 115	

*indicates best trial for each individual.

Summary of the Amount of Knee Bend

These experiments indicate that the best performance occurred for the majority of the subjects when there was a slight bend allowed in the knee joint, approximately 15 degrees. Three of the subjects were definitely better under these conditions. One subject gave the fastest time when no bend was allowed. Another did equally well with no bend and a 15 degree bend. As a composite result it may be stated that the bend allowed in the knee should be small. It was noticed that a large bend (45-90 degrees) was very fatiguing.

3. *The Width of the Kick*

The Problem

The proper width of the kick for maximum efficiency is of considerable importance. In all modern literature describing the crawl stroke, it is usually stated that the width of the kick decreases as the speed increases and vice versa. It is necessary to make a definition as to what is meant by the width of the kick as it is used here. In these measurements the width is given as the opening between the legs from ankle to ankle. This seemed to be the most practical measurement to make for two reasons. First, this opening can be seen readily by an observer in visual observation or on the screen. Secondly, a tie between the legs is adapted to this kind of measurement.

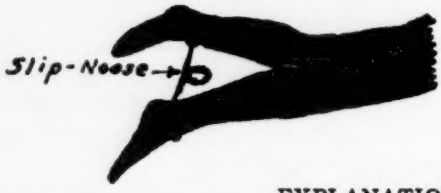
Solution by Experiment

In order to have a check upon the maximum opening between the ankles, a KICK-TIE was used to limit the opening to a certain desired maximum each time.[28] (Illus. X). It is known that the kick did not exceed the measurement given by the tie. The width of the

[28]This kick tie was suggested by Dr. P. V. Karpovich.

ILLUSTRATION X

SLIP-NOOSE FOR MEASURING KICK.



EXPLANATION

The small rope may be attached as shown being tied to the ankles with knots which do not slip. In the middle of the rope between the legs is a slip knot drawn tight so that it will not slip easily because of the pressure of the water.

kick may not be judged with accuracy by the eye alone due to refraction. The widths as given in the table may be considered to be approximately correct. In each case the kicks were made as fast as possible with the kick as wide as the tie would allow. Four widths were tried, one very narrow (4″), one wider (8″), another still wider (14″) and one very wide (24″). Each subject kicked 60 feet with the legs limited to the widths indicated. The data represents the best of two trials.

Subject	Very Narrow (4 in.) Sec. Beats	Narrow (8 in.) Sec. Beats	Wide (14 in.) Sec. Beats	Very Wide (24 in.) Sec. Beats
M. S.	*23.2 - 135	25.0 - 114	36.0 - 118	40.0 - 120
D.	26.0 - 96	24.5 - 85	22.0 - 80	*16.8 - 55
W. P.	20.4 - 122	*20.0 - 99	20.2 - 84	22.6 - 79
T. Y.	21.2 - 106	*19.0 - 87	21.8 - 80	27.8 - 77
T. K. C.	16.2 - 106	15.2 - 75	*15.0 - 62	16.8 - 55

* indicates best trial for individual.

Summary of the Width of the Kick

The data given above indicates that individuals are different in their adaptability to different widths of kicks. One swimmer was best on the narrowest kick. This swimmer was of frail physique and it is thought that he did not have the power to kick the wider kicks efficiently. Girls may be of this type, capable of kicking a very fast, narrow kick, but still not making the speed of a vigorous boy with a wider kick. Two swimmers were best on the 8 inch width. However, the two kicks which were the speediest of the whole group were the wider kicks. One of these was best with the 14 inch kick and another best with the 24 inch kick. The last subject was a person with tremendous strength throughout the body. As a general conclusion it seems that for best speed a person should kick as wide a kick as his physique will stand, up to a maximum width set by the limitations of resistance. At top speed a point will be reached when the legs are opened about 24 inches; this is a maximum for two reasons, (1) to open wider than this will cause a tremendous increase

in resistance,[24] (2) the down-kick swirls become retarding enough at approximately this width to become of some consequence. (See Illus. XI). At slower speeds the legs may be opened wider. The kick should be operated within the depth of body displacement as nearly as possible. Strong and athletic subjects who have had the advantage of considerable training might kick a kick as wide as 20 inches and get greater speed than with any other type. Weismuller's kick during fast swimming measured 19.3 inches on the screen.

4. *The Rate of the Kick*

The Problem

The rate of the kick is related to the width of the kick. As a rule the width decreases in direct proportion to the increase in rate. This problem has a bearing upon the theories of the six, eight, ten or even greater number of beats per cycle as the best.

Solution by Experiment

Reference is made to the data already presented in the preceding section on the "Width of the Kick." It would seem that the rate of the kick should be determined by the rate which accompanied the most efficient trial for speed. This would probably be true for sprinting when maximum speed was desired. A study of the data shows that the fastest swimmers seem to have relatively fewer beats than the swimmers with poorer kicks. It is evident that a swimmer with a poor kick would have to kick more of the beats to cover a given distance than a swimmer with an efficient kick would have to take. This is because the swimmer with the more efficient kick would go a greater distance per kick and reach the end sooner. In the data referred to in the preceeding section only one swimmer was more efficient with the highest number of beats. (see subject M. S.). This subject lost in efficiency as the beats decreased from 135 to 114. However, this subject seems peculiarly adapted to speed in the leg action and not for strength. In all other subjects the reverse was true, the greatest number of beats causing a loss in efficiency. One subject (D) was the most efficient with the smallest number of beats, 55. His kick was a wide one. One other subject was most efficient with a relatively low number of beats, 62. Two subjects were most efficient with a relatively high number but not their highest.

Summary of the Rate of the Kick

Here again the evidence seems to point to individual differences, just as in the study of the best width of kick. It emphasizes the point

[24] Dr. P. V. Karpovich's studies on the resistance which the water offers to bodies passing through it indicate that the resistance varies as the square of the speed approximately at 2 yds. per sec. See Ganot's Physics, Wood & Co., N. Y., 1905, p. 34.

that width and rate are intimately related, a wide kick usually calling for a slower rate, and vice versa. Individuals, however, seem better able to maintain maximum efficiency with kicks which fit their structure. Individual tests may be necessary to determine this for each individual.

Muscular Action of the Crawl Flutter Kick

Knowledge of Muscular Action in Kick is Important

The knowledge of the muscular groups which carry the principal burden in the crawl flutter kick is considered important for several reasons:

(1) Gives Knowledge Why Swimming Exercises Big Muscles of Trunk.
(2) Gives Basis for Design of Training Gymnastics.
(3) Gives Knowledge of Muscular Groups for Massage.
(4) Enables Proper Explanation of Fatigue.

Nature of the Evidence

The evidence of the muscular action comes from several sources. These may be summarized as follows:

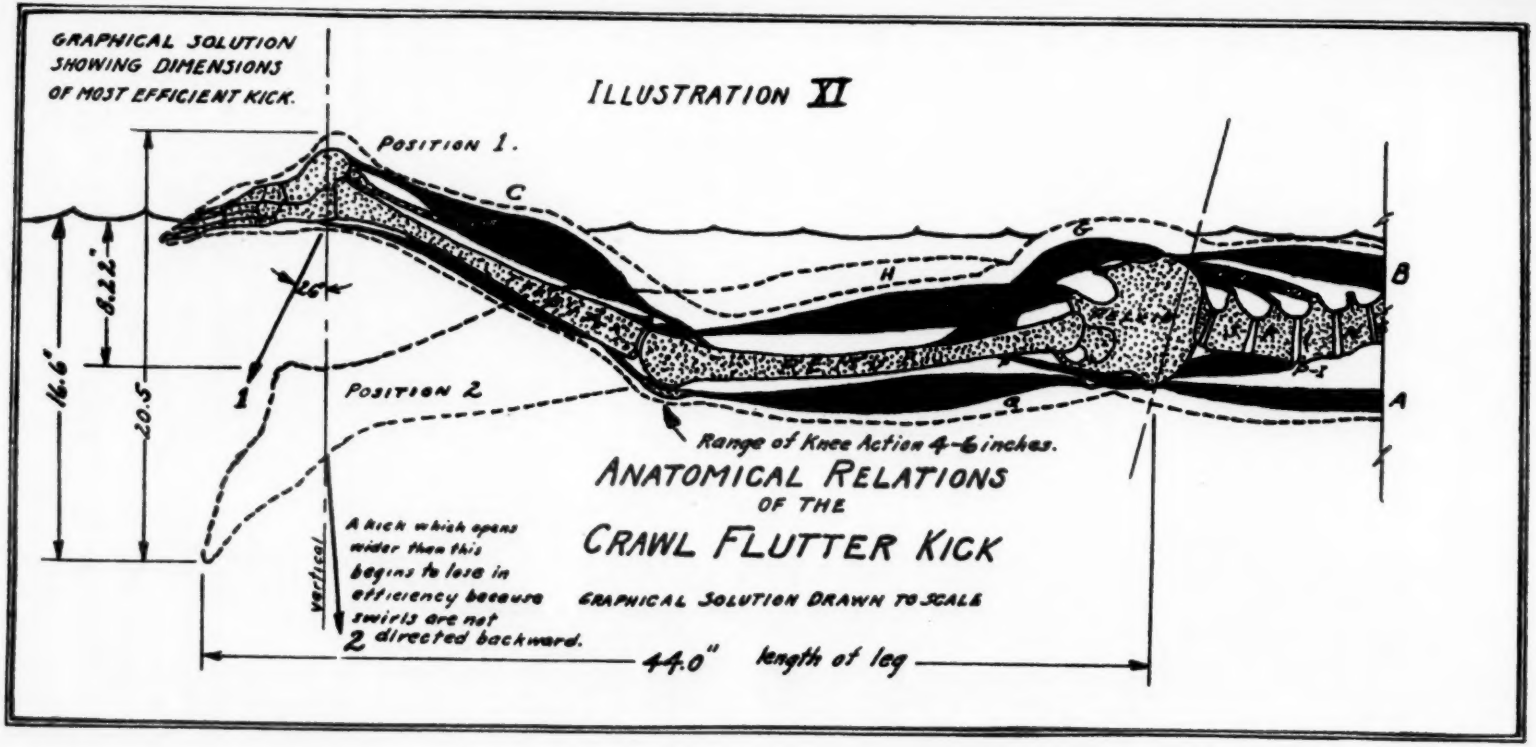
(1) A Study of the Nature of the Movements as in the Preceding Sections.
(2) A Study of the Localization of Fatigue in Muscle Groups After Vigorous Action.
(3) Palpation of the Muscular Groups While in Action.
(4) Dynamometry.

The Flutter Kick Movement

It has been seen that the flutter kick movement is a very compound one involving practically all the muscles of the leg as well as those of the abdominal and lower back regions. (Illus. XI). The movement is one of extension and flexion of the foot, extension and flexion of the leg, and extension and flexion of the thigh upon the pelvis. The muscle groups which bear the principal burden of this action may be detected by the evidence of fatigue.

Fatigue Localization in the Muscle Groups

Every coach has had the experience during his coaching career of complaints of localized fatigue after strenuous drill on the flutter kick. The writer has seen some swimmers almost unable to stand on their legs. The complaints are usually directed to the aches which occur in the muscles of the thigh on the front of the leg, known as the "Quadriceps Group." The muscle in this group which is known as the "kicking muscle" is the Rectus Femoris. It bears the principal burden of extending the leg on the thigh. The Down-kick is made


GRAPHICAL SOLUTION SHOWING DIMENSIONS OF MOST EFFICIENT KICK.
ILLUSTRATION XI
POSITION 1.
POSITION 2
C
H
G
B
A
16.6"
8.22"
20.5
26°
1
2
vertical
A kick which opens wider than this begins to lose in efficiency because swirls are not directed backward.
Range of Knee Action 4-6 inches.
ANATOMICAL RELATIONS OF THE CRAWL FLUTTER KICK
GRAPHICAL SOLUTION DRAWN TO SCALE
44.0" length of leg

suddenly and with great speed. The Rectus Femoris feels this unusual strain because it is not a muscle of great cross-section. Illus XI shows a diagram of the muscles which are used in the flutter kick action. The muscles are diagrammed as groups. It can be noticed that the origin of the Rectus Femoris is on the pelvis and the insertion is into the patella ligament and then into the tibia. *The foreleg cannot be kicked downward with force without exerting considerable force upon the pelvis.* The effort tends to flex the thigh upon the pelvis. The Psoas and Illiacus muscles (shown as P-I group) come vigorously into contraction to reinforce the action. The Abdominals (shown as A group) act likewise. In the meantime, the thigh is prevented from being flexed by the synergic action of the lower back muscles aided by the Gluteus Maximus as a tensor of the fascia lata.[25] (Shown as G group.) This cooperative play of the posterior extensor group and of the anterior flexor group, acting as it does to prevent the dropping of the knees excessively as is so often seen in beginners, is one of the finely adjusted coordinations which must be learned before an efficient kick can be mastered. *The abdominals come vigorously into play during hard kicking efforts with the flutter action.*

Palpation of the Muscles

One experiment may be tried which gives some indication of the muscular action. First, a swimmer may feel the play of the abdominal muscles by feeling them with one hand while kicking a flutter board. A constant play of these muscles will be felt, and at high speed they seem to be in constant contraction. If the swimmer kicks the flutter kick while holding to the gutter, another person may feel the vigorous action of the lower back extensors and the Gluteals. *During the action of the Up-kick the whole posterior extensor set of muscles comes into play to lift the leg.* The muscles of the lower back play a very important part in holding the pelvis fixed during the action of the G and H groups (Gluteals and Hamstring). At the start of the Up-kick it is thought that the Gluteals act more to lift the leg (G group), but this action is soon followed by the contraction of the C group (Gastrocnemius and Soleus) to extend the foot at the ankle joint and the contraction of the H group (Hamstrings) which act to help lift up the leg and finally to flex the knee. Here again, the possibility of over-action is prevented by the action of the Q and the other anterior groups.

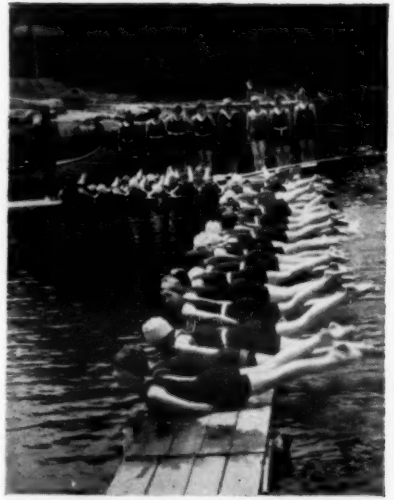
Summary and Implications of the Muscular Action in the Kick

The central source of power in the crawl flutter kick is in the body muscles of the back and abdomen acting to flex and extend the thigh upon the pelvis in a rapidly reversing and finely balanced action.

[25]Gray, Henry, "Anatomy of the Human Body," Phila., 1924, p. 480.

ILLUSTRATION XII

Developing the Flutter Kick by Land Drills



Warm-up Drill Before Swim

On the Stomach for the Up-kick

On the Back for the Down-kick

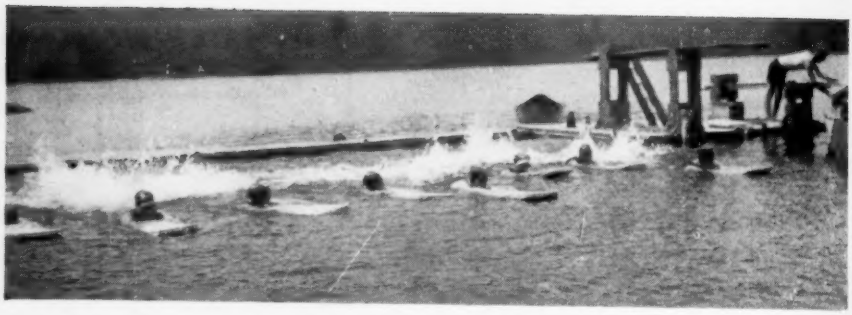


ILLUSTRATION XIII

Developing the Flutter-kick by Water Drills

The effects of fatigue are felt more in the Rectus Femoris muscle because the cross section of this muscle is small compared to the work it has to do. Beginners complain of fatigue in three places, the thighs, the small of the back, and occasionally the abdomen. Only long and faithful practice will develop the endurance and control necessary to swim this kick for long periods with ease. The use of land drills will undoubtedly aid tremendously. It has been proved experimentally that experts can kick more flutter kicks on land than average swimmers. In a group measured at Brimfield, the experts kicked 17.1% more kicks than swimmers of average crawl ability. Improvement has also been shown in swimmers because of practice of land drills on the kick. One swimmer tested improved 20.25% in speed in two months intensive work on land exercises. It is believed by the writer that land drill is more profitable for the development of strength and control for the hip action, the water probably better for the development of the sensory pressure areas of the foot. The action of gravity makes the land practice more vigorous than practice in the water.

Dynamometer Tests of Flutter Kick Strength

A test of the back and abdominal strengths of a group of expert crawl swimmers as compared with a group of average crawl swimmers showed the experts to be 32% superior in abdominal strengths and 19.6% superior in back strengths. These tests were taken in the flutter kick position on a plinth specially constructed for the purpose at Springfield College.[26] The experts as a group were 51.8% stronger in both the back and abdomen than a group of average girl swimmers. This same group of experts was superior in speed to the average men group by 44.7% and to the women by 66.0%. *This indicates that speed in the flutter kick is directly proportional to the strength of the back and abdominal muscle groups.* Swimming the crawl kick is undoubtedly an excellent means of developing lower back and abdominal strength. The kick calls for considerable effort to overcome the resistance of the water and also to overcome the inertia in the legs as the direction is so rapidly changed at high speeds. In this respect, swimming seems to be predominantly an exercise of the big-muscles of the body.

This research might go on and on but somewhere it must be brought temporarily at an end. Some problems have been touched upon and if they help in laying a sound basis for pedagogy of the kick subject for the refinements of later investigations, the task will have been made worth while. Sincere appreciation is expressed to Dr. J. H. McCurdy, Dr. P. V. Karpovich and Dr. Wm. Skarstrom for reading the manuscript, or parts of it, and from time to time making valuable suggestions.

[26]Data presented to the International Y. M. C. A. College in thesis, "Objective Tests of Swimming," by the writer, 1930.

The Supervision of Practice Teaching in Physical Education in Undergraduate Institutions in the United States*

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INTRODUCTION

Statement of the Problem

THE purpose of this study is to secure data on such aspects of the supervision of practice teaching in physical education as will yield a picture of the practices which prevail in that field of teacher training in undergraduate institutions in the United States offering professional courses in physical education.

No reference to a study of exactly this nature has been discovered up to the present time. A similar study in general practice teaching has been made by Haertter and Smith[1]; reference will be made to it wherever it is possible to make a comparison.

Procedure

The data in this study were secured primarily by means of a questionnaire,[2] sent to 152 institutions listed by Ready[3] as giving professional curricula in physical education. The table which follows gives the number of replies that were received. The 152 institutions are classified into groups according to the length of the period of training.

"Four year public" refers to public colleges and universities offering a four year major course toward a degree. Similarly "Four

TABLE I

Number and Nature of Institutions Replying to Questionnaire

Number of Institutions	Type of Institution	Number of Replies Received
35	Four year public	24
29	Four year private	16
28	Teachers Colleges	11
37	Two and three year	15
13	Special Normals	11
10	Unclassified	4
152		81
24 extra copies sent to above institutions reputed to have additional curricula for men		4
		(56%) 85

* An Abstract of a Thesis submitted to the faculty of the Graduate School of the University of Minnesota.

[1] Haertter, L. and Smith, Dora. An investigation into Methods of Student Teaching in 32 Colleges and Universities. Educational Administration and Supervision 12 (December, 1926) pp. 577-95.

[2] See Appendix for sample of questionnaire.

[3] Professional Courses in Physical Education for Teachers. U. S. Department of Interior No. 6879 (1926).

year private" and "Teachers Colleges" are classifications used for the other two types of institutions offering a four year curriculum. "Two and three year" refers to public and private universities, colleges, Teachers Colleges, and Normal Schools giving either two or three year courses. "Special Normals" refers to special schools which offer only a physical education curriculum.

A request was made on the questionnaire blank for the enclosure of a sample of a formal observation outline if one were used in supervision. Twenty-nine such outlines were submitted; seven of these were of a general type used by the institution in all its practice teaching departments and 22 were special forms used only in the supervision of physical education practice teaching.

A supplement to the questionnaire labeled "Form for the supervisor" was enclosed with the questionnaire and consisted in a list of questions concerning the training and duties of the supervisor.

The method used in the curriculum study was more indirect than the preceding method. The bulletin of each institution was studied and whenever a bulletin was lacking in clearness, a direct contact was made with the institution by letter; twenty such letters were sent. In all 70 curricula were studied and outlined carefully. Only a very brief summary of this detailed study appears in this abstract.

In substance Chapter I deals with the student and faculty personnel of the institutions contributing information to this study. In the thesis itself, the discussion treats in detail, the size of the student enrollment, and of the teacher training staff, the number of supervisors and practice teachers, and the training and experience of the supervisors.

Chapter II gives a survey of the students background for teaching. The facts of the background considered important in this study are the nature of the curriculum and the nature of the recognition given upon completion of the course of training.

Chapter III treats the factors concerned with practice teaching, i.e., the type of practice teaching, the amount done, the variety of activity used, the time devoted, the place and age levels used in the practice teaching.

Chapter IV deals entirely with the supervisor's activities, i.e., the factors involved in lesson planning, the supervisor's visit, supervisory activities immediately after the visit, and the supervisor's load.

This abstract presents the chapter summaries only. In these summaries, a comparison has been made between the four year major institutions, i.e., those institutions requiring four years for the completion of a major in physical education, and the shorter course institutions, i.e., those institutions requiring three years or less to complete a professional course.

SUMMARY OF CHAPTER I

Enrollment

1. In enrollment for the two year interval, the shorter course institutions have well over twice as many students as the four year major institutions; the figures are 42.7 and 18.1 students respectively. For the four year interval, the enrollment of the shorter course institutions is almost twice as large as that of the other group; the figures are, 26.4 and 14.2 students respectively.

2. The shorter course institutions have a greater retaining power, approximately ten per cent in the transition from the first to the second years, but less by approximately twenty-five per cent in the transition from the second to the third years and from the third to the fourth.

Number of Students per Teacher

In the number of students per teacher, the shorter course institutions exceed the four year major group by approximately twice as large a figure in both the two and four year interval.

Number of Practice Teachers per Supervisor

The supervisory burden of the shorter course institutions is approximately twice as great as that of the four year major institutions.

Training and Experience of the Supervisors

1. In the investigation of the training of the supervisor, it was found that 80 per cent of all supervisors had degrees; in the case of the shorter course institutions the figure was 58 per cent; while in the four year major group, the figure was 96 per cent.

2. Little graduate work was done, but that mentioned was done in physical education.

3. The average number of years in which the supervisor had taught physical education was a little greater in the case of the shorter course group of institutions, but the variety of school and variety of activities in which supervising was done was practically the same for the supervisors of the two groups of institutions.

In general, the shorter course institutions have a larger problem of number than have the four year major institutions for they have many more students per teacher and more practice teachers per supervisor. The supervisory personnel which cares for the larger number of practice teachers has relatively greater advantages in experience, but much less in such training as is represented by a degree.

SUMMARY OF CHAPTER II

The shorter course institutions show a much more sharply vocationalized curriculum than do the four year major institutions.

In Respect to the Curriculum

1. The four year major institutions require an average of approximately twice as many semester credits as the shorter course institutions in the academic, professional education, and elective fields.

2. The shorter course institutions offer an average number of semester credits in physical education required courses and in practice teaching, which is approximately a third greater than those in the four year major institutions.

In all institutions, in general, of all groups of subjects, e.g., academic, professional education, physical education theory, combination, and practice courses, the professional education subjects are mentioned least frequently and physical education theory subjects the most frequently from the standpoint of required work. The average of semester credits, however, ranks from highest to lowest: academic, physical education theory, physical education practice, physical education combination and professional education.

Recognition Granted Upon Graduation

1. The most frequently mentioned award by the shorter course institutions is the diploma, while that mentioned by the four year major institutions is the degree. Both groups of institutions mention the state teacher's certificate second.

2. The data from all institutions show that the degree stands first and the teacher's certificate from the instutions stands lowest among the recognitions of fulfillment granted upon graduation.

SUMMARY OF CHAPTER III

Conditions of Practice Teaching

The conditions under which practice teaching exists in the two groups of institutions, the four year major and the shorter course institutions, may be summarized in the following way.

Amount of Practice Teaching by Substitutions, Assistance, Observation and Organization

The shorter course institutions offer more practice teaching in observation and organization but much less in assistance and substitution than does the four year major group.

TABLE XXI

Per Cent of the Four Year Major and Shorter Course Institutions Using the Various Kinds of Practice Teaching

Group of Inst.	Observation	Assistance	Organization	Substitution
Four year major	14.3%	24.4%	18.2%	33.2%
Shorter course	28.9%	13.2%	22.5%	15.0%

Average Number of Semesters Spent in Practice Teaching

The four year major institutions have an average of 1.0 semesters per year while the shorter course institutions have an average of 2.3 semesters per year, or more than twice as much for a four year average.

Average Number of Times Practice Teaching Is Done Each Week by the Typical Student

In the number of times in a week that practice teaching is done by the typical student each year, the two groups of institutions are equal, each averaging nearly twice a week per year for four years.

Year in which Practice Teaching Is Done

The average emphasis upon practice teaching in all activities in each institution is greater each year in the shorter course institutions except in the senior year when the four year major group has a slightly higher average of practice teaching activities per institution. The average of practice teaching activities in both groups increases steadily each year.

The shorter course institutions have the highest average of practice teaching activities in all years except the senior year, when the special normals have a close second place to the four year public. The average frequencies of the two groups also show that the shorter course institutions emphasize practice teaching in all activities each year except the senior year when the average for the four year major group slightly exceeds the other figure. Both groups have the highest average of practice teaching activities in the senior year.

Is a Technique Course a Prerequisite for Practice Teaching in Each Activity?

Each group of institutions averages per institution less than one activity in which no technique course is given.

Variety of Agencies in which Practice Teaching Is Done

The shorter course institutions use a greater variety of agencies, e.g., elementary school, junior high, senior high, junior college, senior college, clinics, settlements, rural schools, playgrounds, for practice teaching than do the four year major group.

Additional Activities in which Practice Teaching Is Done

In the number of practice teaching activities in addition to the list of the fourteen most commonly used ones, i.e., Orthopedics, Folk Dancing, Gymnastics, Low Organized Games, Interpretive Dancing, Aesthetic Dancing, Hockey, Basket Ball, Baseball, Soccer, Hygiene, Swimming, Track, Tennis, the four year major institutions have on

the average six times as many mentions of additional activities, i.e., Archery, Captain Ball, Clogging, Football, Crew, Hit Pin, Baseball, Riding, Speed Ball, Stunts, Tumbling, Volley Ball, Wrestling, as the shorter course institutions.

Type of Support for Agencies Used in Practice Teaching

Both groups use the public supported agencies to the same extent. The shorter course institutions use privately supported agencies more than the four year major group uses them.

Number of Minutes Spent in Practice Teaching in the Elementary School, High School, etc.

The shorter course institutions have higher averages in the number of minutes spent in practice teaching in each level of the curriculum.

TABLE XXXIX

Average Number of Minutes Spent in Practice Teaching in Four Year Major and Shorter Course Institutions

Group of Inst.	No. Inst.	Elem.	H. S.	College
Four year major	47	30.8	46.6	43.8
Shorter course	22	36.7	54.2	47.

Age Levels Used in Practice Teaching

Every age level is used much more by the shorter course institutions than by the four year major group.

SUMMARY OF CHAPTER IV

Supervisor's Activities

The supervisory activities in the shorter course and four year major institutions may be summarized in the following way.

Lesson Planning

1. Use of a formal lesson plan.

Three-fourths of all institutions use a formal lesson plan; the shorter course group use it more than the four year major group by ten per cent.

2. Frequency of independent lesson planning.

Three-fourths of all institutions have independent lesson planning. The two groups of institutions are about equal in their frequencies of independent lesson planning, and in the comparison with the Haertter and Smith study, there seems to be greater independence in planning by practice teachers in physical education than by practice teachers in other fields.

3. Checking of plans.

About three-fourths of all institutions check plans before teach-

ing. Both groups are about equal in the frequency of checking plans before teaching.

4. Who checks the plans?

The shorter course institutions practically always have the supervisor check the plans; the four year major group have the supervisor do it about half the time. Practically all institutions require the correction of unsatisfactory plans before teaching.

Factors Concerned with the Supervisor's Visit

1. Frequency of supervisor's visit.

In general the four year major group have more frequent supervisory visits on the average.

TABLE XLV

Frequency of Supervisor's Visit in the Four Year Major and Shorter Course Institutions

Frequency	Four year major	Shorter course	Av. of averages
1-1	3	2.3	2.6
1-2	2.6	1.7	2.2
1-3	1.8	2	2
1-4	1.2	1	1.2
1-5	1	1	1
1-10	1	1	1
2-3	..	1	1

2. Amount of time practice teacher is alone.

The practice teacher is alone much less in the four year major institutions than in the shorter course institutions.

TABLE XLVII

Amount of Time the Practice Teacher is Alone in the Four Year Major and Shorter Course Institutions

Group of Inst.	No. Inst.	Seldom	Half	Maj. of Time
Four year major	46	33%	15.6%	9.4%
Shorter course	20	20%	22%	17.5%

3. Proportion of time practice teacher acts as a supervisor.

The fact that the shorter course institutions use the practice teacher for supervising more than the four year major group do, is quite in keeping with the fact that they have more practice teachers per supervisor.

4. Manner in which the supervisor observes the lesson.

The four year major institutions are less dependent on mental notes than the shorter course group.

TABLE LI

Way Supervisor Observes Lesson in the Four Year Major and Shorter Course Institutions

Group of Inst.	No. Inst.	Written Notes	Mental Notes	Formal Outlines
Four year major	47	65.9%	21.2%	19.1%
Shorter course	22	63.6%	40.9%	18.1%

Post-visit Supervisory Activities

1. Who gives the criticism?

The shorter course institutions use all types of supervisors, i.e.,

institution supervisor, school system supervisor, critic teacher, student supervisor, more than the four year major group. Both use the institution supervisor most of the time.

2. Student supervisor's report on supervision.

The majority, or 63.3 per cent, of all institutions either do not have student supervisors or else do not require them to report. Of the institutions answering this question, the shorter course institutions have much the larger per cent of student supervisors reporting.

3. The way in which practice teacher reports on own teaching.

Practically all use the oral type of report; the formal outline is used least. Of those institutions that do use the formal outline, the four year major group has a slightly higher frequency.

4. Accessibility of written criticism.

The written criticism is more accessible to students in the four year major group, but less accessible to other supervisors.

5. Relation of number of interviews to the number of visits.

The majority, or about 70 per cent, of all institutions have an interview subsequent to every visit. Considering each group separately, a higher per cent, i.e., ten per cent of four year major institutions have the 1-1 relationship.

6. Special methods of assisting weak teachers.

The two methods used most are the individual conference and special demonstration. The four year major group use the individual conference twice as much as do the shorter course group. Both groups use the method, special demonstration more than any other, and the shorter course group use it much more than do the longer course group.

7. Supervisor's rating.

A. Methods used in rating practice teaching. The majority, or 61 per cent, of all institutions reporting use the A. B. C. method of rating. Only three, and they were four year major institutions, attempted a more objective method.

B. Personal qualities. The four year major group tend to rate more personal qualities than do the shorter course group.

Supervisor's Load

1. Variety of activities which the supervisor is now supervising.

The averaged averages of the two groups of institutions show little difference.

2. Average number of practice teachers per supervisor.

The supervisors of the shorter course institutions have an average of six practice teachers per supervisor while those of the four year major group have 2.9 practice teachers per supervisor.

3. Variety of subjects taught by the supervisor.

The shorter course supervisors have less variety of subject, i.e.,

an average of one subject less, possibly because of their larger supervisory burden.

4. Number of teaching hours in addition to supervising.

The average of both groups is about the same, i.e., 14 to 14.5 hours.

5. Number of hours spent in supervision.

The two groups of institutions are even in the number of hours spent in supervision, i.e., nearly seven hours per week per semester.

6. Duties other than teaching and supervising for which the supervisor is responsible.

The most frequently mentioned duties are administrative and advisory to organizations. The supervisors of the four year major group have a slightly higher average of varied activities than those of the other group.

CONCLUSION

The comparison of shorter and longer course institutions has revealed facts which sometimes corroborate and at other times contradict statements which have been made about them. It has probably been generally understood that the shorter course institutions attracted a larger number of students than the four year major group partly because the former is the older group of institutions and partly because the short term of training means quicker remuneration; the figures show this to be true. There are just about twice as many students and practice teachers in the shorter course institutions. It follows of course that the greater number of students raises a problem of faculty personnel; since the shorter course institutions have relatively the same number of staff and supervisors as the four year major institutions, the implication is that the students of the former group receive about half as much individual attention as those of the longer course group.

The supervisors of the shorter course group bring to their institutions a training which is often less than that of the supervisors of the four year major group as far as the degree is concerned, but which has a variety of experience equal to that of the latter, and in amount a little greater. The fact that practically all the graduate work done by supervisors seems to be done in physical education raises a question of just how much graduate work is being done in allied fields such as in professional education, e.g., administration and supervision; in science, e.g., physiology.

The data on the curriculum show that there is the greatest frequency of mention in all institutions of physical education theory courses, although in actual number of credits, they stand in second place, with first place being held by the academic subjects; there is least frequency of mention and also the lowest credit requirement in professional education courses. What courses and just how many

credits should be required in each group of subjects is a large problem in itself and raises such questions as these; should professional education courses stand in lowest place in the training of a physical education teacher? How many of the teaching technique courses in physical education could be eliminated by a general methods course given by a person who could give illustrations from the field of physical education and possibly guide the teaching in that field? Some institutions omit purely practice courses, some require them in the freshman and sophomore year, and others require them throughout. What are the advantages of purely practice courses? Just how many combination courses of practice and special technique of teaching should there be, and when should they be given? It is a well known fact that many teachers of physical education have a large supervisory function, and yet in this study, supervision is mentioned by only three institutions in the field of physical education theory, and not at all in the field of professional education. Should there not be a job analysis made of the curricula in institutions training teachers and supervisors of physical education?

The degree as an evidence of completion of a course of training has the greatest recognition by all institutions. Some evaluation of the significance of the degree conferred by the various types of institutions would be valuable now that a number of institutions are establishing graduate departments.

Because of the larger number of practice teachers, the conditions under which practice teaching is carried on are more elaborate from almost every standpoint in the shorter course institutions than in the four year major group; there is twice as much time spent on practice teaching, there are more agencies, there is more use of all grade levels, and there are longer periods at every level of the curriculum than in the longer course institutions. The following facts suggest that the practice teacher in the shorter course institutions receives less individual help than one in the four year major group; in general the supervisors of the shorter course institutions supervise less and the practice teachers supervise each other more than in the longer course group; the supervisor in the shorter course institutions uses a more general method of supervising, i.e., mental notes; a lower per cent of the shorter course institutions has a 1-1 relationship between the number of interviews and the number of visits; the shorter course group use the method of individual conference in assisting weak teachers about half as much as do the other group; the shorter course institutions attempt the rating of fewer personal qualities in the practice teacher than do the four year major group. How much individual help should be given, and whether it should be given equally to all practice teachers, are some questions that might be raised.

The fact that practically all methods of judging practice teaching

in physical education are highly subjective makes necessary the study of scientific methods of teacher rating.

The majority of institutions report independent lesson planning by the practice teachers; in comparison with the study by Haertter and Smith, lesson planning is more independent in physical education than in other fields of practice teaching. Just how independent should lesson planning be?

The kind of practice teaching chiefly used by the shorter course group, i.e., observation and organization, is more suited to large numbers of practice teachers than the other two types, assistance and substitution. There is a question, however, as to whether the amount of responsibility and opportunity for initiative involved in the former is as great as in the latter two types.

The fact that the four year major group has many more kinds of activities in which practice teaching is done is doubtless due to the fact that the teacher training agencies in this group are, for the most part, departments in institutions where the student body consists in a larger group than the majors in physical education, and a greater variety of activity is desirable. A graduate of a four year major institution has a greater repertoire of activity and more variety of practice teaching opportunity. The fact that in both groups of institutions, practice teaching starts in the freshman year and increases steadily each year, raises the question of how much should be done each year.

The average supervisor's program in both groups of institutions is about 22 hours per week per semester. Whether or not the supervisors interpreted the term "supervision" to include time spent on lesson plans, visiting, conferences after the visit, and so forth, is not quite clear. A study of the duties of a physical education supervisor and of the amount of time involved in them and particularly in conferences needs to be made before an average load can be determined.

The determination of salaries was considerd but finally not attempted; it is an interesting problem.

In general, every phase of this study raises questions to which as yet, we can give answers which are chiefly personal opinions. More studies in this field are greatly needed to give a scientific basis for the philosophy and procedure of supervision of physical education.

BOOK REVIEWS

NORMAL FACTS IN DIAGNOSIS. Harris and Finesilver. F. A. Davis & Co., 235 pp. $2.50.

The material as presented in this book serves a two fold purpose. It offers valuable detailed information for classroom study and at the same time is written attractively enough to interest the general reader. The various methods used in presenting the different phases of a medical examination are rational and clearly enough outlined for the comprehension of other than the medical student. Furthermore, sufficient space is given for many helpful illustrations that make plain the routine used in the modern methods of diagnosis. I would not hesitate to recommend this book for classroom use by students of Physical Education.

George A. May, M. D.
Director of Waterman Gymnasium,
University of Michigan

PLAY GAMES AND OTHER ACTIVITIES. By Albert B. Wegener. The Abingdon Press, 1930. 182 pp. $2.00.

The author's purpose has been to provide an all around game book having brevity, comprehensiveness, classification of similar games, a standardized nomenclature and information on how to invent or modify games.

It will be of particular interest to those who direct play and games, especially for clubs and religious organizations, desiring a large variety of material involving "Physical Play," "Mental Recreation," "Sociability," and "Play Pointers," within the covers of one book.

Mr. Wegener's book is different from others of the game type in that it lists together all play activities having a like objective, making selection easier.

For example: Under "Physical Play" is the subdivision "Speed Play," further divided into a list of twenty-two kinds of races varying from "racing steps" to "passing objects races." This general analysis, subdivision, explanation and listing of activities is carried on throughout the book. His "Physical Play" has the additional classification of "Strength Trials and Contests," "Skill Play," "Physical Endurance Tests," "Personal Capacity Tests," and "Outings," a total of one hundred four pages.

Under "Mental Recreation" activities are listed, described and classified as "Knowledge Tests," "Mental Control" (poise), "Reasoning Play," "Creative Recreation" and "Fads and Fancies," twenty-seven additional pages.

Part III deals with various aspects of "Sociability," with helpful hints on socials and parties, special programs, social mixers, chance games and joke games, with additional parts devoted to singing and dancing.

Part IV, "Play Pointers," offers sample lists of games for various occasions, discusses the conduct of tournaments and leagues and concludes with a short bibliography of sources of books for play directors.

The author again (Wegener's "Track and Field Athletics," A. S. Barnes and Company, 1928) shows his ability as a pen and ink artist with two hundred ninety small figure illustrations, condensing all this material on seven pages. The book has a good, usable index.

A. S. Hotchkiss, Sup't.
Division of Physical Education and Athletics, Social Science Department, Tennessee Coal, Iron and Railroad Co.,
Birmingham, Alabama.

THE NORMAL DIET. By W. D. Sansum, M.S., M.D. C. V. Mosby Co., St. Louis, Mo., 1930. $1.50.

This is not just one more book on a subject of current popularity. It is, rather, an old, acknowledged text brought up to date by the author, an authority in this field. The fact that it has been an authentic source for a number of years enhances its value.

The joy of reading "The Normal Diet" is in its high degree of understandability. One is quite simply, yet forcefully, led to a comprehension of this important field which could be made impossible for the average reader by the use of technical phraseology and formulae. Instead, its simplicity and style is refreshing. One feels an intimacy with the author as he cites case histories.

Another asset is its universality. Parents, nurses, physicians, students, home economic teachers, and the patient himself, will find it helpful as a source of information. The discussion of the types of acidosis is particularly enlightening and the section on "Diet Menus," with its samples of menus for different purposes, is a handy practical aspect of the book.

For physical education teachers who are seeking basic material for health education courses, and for athletic coaches in need of information concerning the diet in training, "The Normal Diet" is recommended.

Allen G. Ireland, M.D.
State Supervisor of Physical Education, New Jersey.

PRINCIPLES OF HYGIENE. By Thomas A. Storey. Stanford University Press, Stanford University, California. 475 pp. $3.50.

This book is filled with an enormous quantity of information, illustrated with line drawings, and is obviously intended as a text book for college students. Its subject matter is advanced and authoritative. The book is divided into two parts: constructive hygiene and defensive hygiene. The first part is largely a consideration of human physiology taken up in the following order: the cell; heredity; nutrition; excretion; physical exercise; play; rest; contributory causes of health; and the application of the laws of constructive hygiene.

The second part deals with the practical application of present day knowledge concerning the prevention of disease and includes among other things: defensive hygiene of heredity; excesses; health hazards; mechanical injury; injurious physical agents; chemical causes of disease; micro-organisms and disease; unknown causes of disease (cancer); carriers of disease; mental hygiene; and the achievements and failures of modern scientific hygiene. The appendix contains tables of weights and mortality and the classification of mental diseases. The book was written by an exceptionally well trained scientist, who has spent his life in teaching and practicing hygiene and physical education. The author has been a leader in his field for many years.

This book should prove of incalculable value to the teacher of hygiene in colleges. It is too advanced for use with high school pupils but should be read by every high school teacher of hygiene for his own advancement.

Lawrence B. Chenoweth, M.D.
Professor of Hygiene, and Director of Students' Health Service, University of Cincinnati.

MANUAL OF PHYSICAL EDUCATION FOR ELEMENTARY GRADES. By Brace and Pickney. Bureau of Nutrition and Health Education, Division of Extension, University of Texas. 288 pp.

In several respects, this manual differs from the ordinary run of state courses of study, which, in itself, is a merited attribute. For one thing, there is an excellent treatment of tests and measurements, a quality that is in accord with the high standard set by the senior author in previous work on that subject. It consists of more than mere description, for the principle of meas-

urement underlies the program, and many practical applications are suggested. Another feature is an attempt to guide the teacher in coordinating the essential phases of physical education and of health education, but not to the point of amalgamation, as other course-makers have mistakenly tried to do. Indeed, the two fields are defined each as nearly complete entities, with this contact however, "health is one of the outcomes of desirable physical activities—an objective of physical education just as it is an objective of all education." There is further evidence to indicate that the authors are not confused on this point. Sample lessons on health education are given and there are tests by which results may be measured. Still another feature is the attempt to chart the program by months, weeks, and days and by grades and sexes. Although not an innovation, and there are leaders who decry the value of this plan, it gives promise of being a distinct aid to the teacher who plans his work carefully.

A feature which the authors evidently set out to stress is the liberal offering of objectives. Little is left to the knowledge and the imagination of the instructor. A not uncommon failing of teachers is offset thereby, in so far as it is possible to do so in a course of study.

The manual makes it possible for the busy teacher to plan lessons purposefully and, later, to use a standard of measurement by referring to the same chart that lists the objectives.

If any criticism is due in face of the excellent product attained, it would be that the presentation of the program is rather difficult for the classroom teacher for whom the manual is primarily intended. It requires not only study but a more thorough comprehension of the principles underlying physical education than is possessed by the average teacher. The teacher or supervisor trained in physical education should find it a most helpful guide. As the basis of work in teacher-training institutions, it should serve admirably. And the teacher who really desires to improve his physical education program will, in spite of the study entailed, find the manual a source of inspiration and practical help.

The manual itself consists of 288 pages. It is of good quality material and type and well bound, although it would be improved by a different organization of the subject matter and the substitution of another type for italics. It is intended for grades one to six inclusive of the elementary school. A fact of interest is that it was prepared not for Texas alone, but for the states of the South. Undoubtedly, it will prove to be an important stimulus to the development of physical education in that section of the country.

Allen G. Ireland, M.D.
State Supervisor of Physical Education, New Jersey.

THE BOOK OF FENCING. By Eleanor Baldwin Cass. Lothrop, Lee & Shepard Co. 375 pp.

The author, Eleanor Baldwin Cass, has for thirty years been one of America's most outstanding exponents of the theory and practice of fencing.

There is no publication in my library of physical education books that I prize more highly than a treatise on fencing. For years I have searched for such a book among the American publishers' lists, but none could be found to satisfy my longing. Today we can say we have an American edition of Fencing.

I am especially interested in the manner the book has been arranged; it is valuable for the history teacher, the arts teacher, the dramatic arts teacher and those interested in Literature and Arts.

This book gives one a clear conception of the place the sword has taken through the ages. It is the most highly honored of all weapons. Ever since the bronze age swords have played their part in history.

The author explains general terms and principles. She includes a description of swords, cutlasses, scimitars,

rapiers, and short daggers or poignards; also a discussion of the basic principles of attack and defense with any weapon or combination of weapons; and a description of the target.

The interesting history of the development of sword play and also of the duel carries one back into the midst of the Elizabethan and Shakespearean days. The reader also gains a glimpse of knightly days in France, Germany, Spain, England and the Orient.

Four chapters are taken up with foil instuction; every detail is given. If the plan of lessons is carried out the student will have ample opportunity to become proficient in the art of foil fencing.

Another chapter is devoted to the teaching of the epee or duelling sword. Sabre fencing has a colorful introduction depicting the glorious battles of long ago, the engagements of sailors of the Victorian age, and stirring scenes in the jungles. The instructions in sabre are very complete with some excellent illustrations.

So many physical directors are looking for suggestions for their annual exhibitions. Here is a chapter full of help—many forms of exhibitions are given. Private lessons are in outline form and are very easy to follow; also lessons for the small boy or girl. Customs and phraseology that every fencer must know are included.

Fencing scenes from Hamlet, a duel arranged in pantomime form, furnishes valuable material to stage at general assemblies for schools, etc.

Masters in Europe and America, Fencing Activities in America, Olympic Fencing, Who's Who in the World of Fencing, Reports of Fencing Competition in Europe and America, Olympic Team Reports, Fencing Rules, and pages of interesting reading about former champions, complete this volume. In fact, it covers every phase in the study of the art of fencing.

This book will be invaluable to every person interested in Fencing and could well be included in school libraries because of its graphic delineation of fencing, an art which is so often the topic of discussions in Literature.

John Johnstone,
Fencing Coach,
University of Michigan

INDUSTRIAL HYGIENE FOR SCHOOLS. By Williams and Oberteuffer. McGraw-Hill Book Co., Inc. New York City, N. Y. 271 pp. $2.00.

This book is a splendid fulfillment of a great need. Well written, conveniently arranged, and appropriately illustrated, only partly describe this valuable text of 271 pages. It is a book that will appeal to teachers in vocational schools although it should not be confined to that field for its content is sufficiently encompassing to warrant general use. The subject matter is not limited to health practices in the shop but it relates to the industrial worker as an individual, following him into the home and into his avocations as it rightfully should do. It is a book that will serve well the industrial nurse and the executive who seeks a better understanding of the employee's health needs. There is also an instructive discussion of accident prevention in which the hazards peculiar to types of work are explained.

The time has too long been delayed when young persons entering industry will be well-grounded in the principles of safe and healthful living. Physical and mental fitness for the job, together with the knowledge and the habits to fortify the beginner's health should be the first requirements. This book will bring that desirable goal nearer.

Allen G. Ireland, M.D.
State Supervisor of Physical Education, New Jersey.

HEALTH AND HAPPINESS. (Wholesome Living Series). By Williams and Dansdill. Benjamin A. Sanborn and Co., 1930. 106 pp. 73 illustrations and charts.

This new book for the early elementary age starts out with an interesting and good psychological note in its plea for stories that are real rather than tales that are pure or part

fancy. Too much of our health teaching has been of the kind that "peels off" because it has been unsound psychologically. This is an effort to present health activities in the type of situations that are real to children and that can be a part of their own experiences.

The incidents for the most part are of this type and presented with a charm that would attract children. A few times, however, the book goes off into flights of fancy that seem to defeat this purpose. We wish that all parts might have remained true to the main plan.

The activities covered set up a good and complete daily health program. The book is filled with very attractive illustrations in color which are practical and effective in their content. The book is rich in suggestions on things to do that would stimulate the functioning of health practices in the lives of children. There are some helpful question problems suggested. There are a number of charts which would encourage the children to carry on in health activities and would aid the child in getting a measurement of his success.

The suggestions on animal life and the animal stories should make children think of health needs in an interesting way.

The early elementary grade teachers will find help and the children will have happiness in the use of their little book.

Alice Evans,
Couzens Foundation, Western State Normal College, Kalamazoo, Mich.

MASSAGE FOR NURSES AND BEGINNERS. By Maud Rawlins. C. V. Mosby Co. 140 pp. $2.00.

A recent text in Massage for student nurses in schools of nursing has been written by Maud Rawlins. The text is brief, covering merely one hundred and forty pages and will be of definite service for small training schools which cannot employ a large faculty of instructors for their student nurses. Undoubtedly, the author has a feeling for the art of massage. She has taught many years in schools of nursing, and the small text book is written from a ripe experience. The twenty-four chapters are very brief, some merely a few pages on the definite movements in massage. A brief index and table of contents are helpful to the student in lesson assignments. A brief background of the ancient practice of massage is given.

It would be more helpful if the author had prepared a special bibliography and more instruction on the subject of after care of infantile paralysis. Not only would more information on this important subject be of definite value to student nurses, but the facts would be appreciated by graduate nurses in clinic work and private duty. Eighteen illustrations are given in an able manner by Michael Geiger.

The author understands the elements of teaching, and the text will provide sufficient information for teachers in most schools of nursing. The best directions are given in general massage. Here the author is definite and has a wealth of material for instructors. Practically all of her readers would appreciate a bibliography on massage. Undoubtedly students who are interested in this special branch of the subject would be tempted to read some of the interesting older texts on this ancient practice.

Barbara H. Bartlett,
Professor of Public Health Nursing,
University of Michigan.

PRINCIPLES OF WOMEN'S ATHLETICS. By Florence A. Somers. A. S. Barnes and Company, New York, 1930. 151 pp. $1.60.

Here is a book which represents a thorough investigation of the present day facts which bear on the subject of Women's Athletics. Backed by the knowledge that the author has had unusual first-hand experience in this particular field, one can look to her book for interesting ideas and sound guidance regarding the problem of women's athletics in its broader aspects, as

well as in the specific policies outlined for any athletic program where girls and women are concerned.

That the principles underlying a program of women's athletics should be different from that of men's athletics, is a generally accepted truth. But the real reasons for the difference, the nature and degree of difference have not been scientifically established to the extent which is desirable. Miss Somers has made an exhaustive survey of the present literature of the field and the result is rather unsettling, because of the many questions raised which cannot be answered with present day knowledge.

Were it only this fact however, that the author has made us aware of the tremendous need for further research in this field, this book would be justified and significant in its attempt to make physical education sound in its principles and practice. It likewise justifies a fairly conservative policy in the emphasis on competition until more facts are known.

The approach to the Statement of Principles through the sciences basic to education—biology, physiology, sociology, and psychology—is particularly noteworthy, because it directs our attention to the fields where the answers to the questions will have to be found. The effect of athletics on the girl as a whole,—her physical, mental and emotional make-up,—together with the effect on her relationship to society has been considered, and this is of prime importance.

No one can read chapter II on "Fundamental Factors" without wondering even more than Miss Somers suggests, just what changes a program of competitive athletics carried over a long period of time may make in the fundamental nature of girls and women, how this will affect human relationships, and whether society will be happier as a result. Personally, I should like to have had Miss Somers continue the quotation from Joseph Lee and develop the idea found in his concluding sentence, "It is not a perpetual tom-boy we are trying to produce but the enduring values that are to be acquired during that period." We know that the competitive spirit stimulates the fighting tendencies. To what degree this is desirable for girls is a debatable question. One feels sure that Miss Somers is right in stressing sociability and joy in participation as one of the fundamental criteria for judging the rightness of any competition where girls and women are concerned.

The chapter on "Trends in the Athletic Participation and Competition of Girls and Women" surveys the past and present status of athletic activities for girls both at home and abroad in an interesting way. Among the conditions which have influenced the present development of athletics, the author might well have included the part played by college women through their local and national organizations of the Women's Athletic Association. In marked contrast to the history of men's athletics, the athletic interests and needs of college women have had from the beginning the cooperation and backing of the departments of physical education. If we can continue to face the problems of women's athletics as a joint enterprise, there is every hope that competitive athletics can be kept an educational agent.

The section of the book on the Statement of Principles contains material that is more or less familiar, but which can bear repetition in the inclusive and condensed fashion in which it is here presented. The Principles cover the Nature of Athletic Activities,—the Need of the Girl,—the Present Problem,—the Solution of the Problem,—and the Organization of the Program.

The final chapters on Implications and Conclusions succeed in disturbing whatever complacency has been left untouched by Chapter II, as to the need for more knowledge of the facts involved in women's athletics. Miss Somers has cleared the field by presenting issues clearly, and assembling an excellent bibliography. What is needed now is someone to dig in and find more facts.

This book should be read by every

person who is faced with the problems inherent in women's athletics. It is philosophical enough to arouse the interest of the most experienced person, it is practical enough to be a constructive guide to the inexperienced person, and the many hypotheses presented cannot help but prove an incentive to the student of research.

Helen W. Hazelton,
Department of Physical Education
for Women, Purdue University.

EURHYTHMICS, ART AND EDUCATION. By Emile Jaques-Dalcroze. Translated by Frederick Rothwell. A. S. Barnes & Co., 1930. 265 pp. $4.00.

This volume of essays is the latest addition to a considerable literature dealing with that form of rhythmic education developed by the author and called Dalcroze eurhythmics. The work of M. Dalcroze, while it originated in connection with the teaching of music, touches the field of physical education at many points since its central purpose is the development and expression of rhythm through body movement.

The twenty-one essays range in subject matter from the technical aspects of rhythmic movement and its function in education, to a varied discussion of rhythm in art, music, and the theatre. Of the four sections, Eurhythmics, Education, Art, and General, the first two are of greatest interest to physical education. A detailed understanding of eurhythmics, while not prerequisite, is desirable for the most intelligent reading of these sections, which treat, mainly, practical and abstract applications of Dalcroze theory.

The reader may be inclined to question some of the author's physiological and psychological premises, which fact does not, however, detract from an appreciation of the life-long experience and keen insight underlying the arguments. Eurhythmics, indeed, need not validate itself by reference to an obsolete conception of the development of general mental powers or a disproved idea of the values to be gained from deep breathing. Its significance has already been too well demonstrated on an acceptable basis.

The author's somewhat ramified style has been given a clear text by the translator and editor.

A thorough examination of the theory of Dalcroze eurhythmics is indispensable to any serious teacher of rhythmic activities. For that purpose, these essays are an enlightening contribution.

Mary Josephine Shelly,
Teachers College,
Columbia University.

HEALTH AND PHYSICAL EDUCATION FOR PUBLIC SCHOOL ADMINISTRATORS. By Williams and Brownell. Bureau of Publications, Teachers College, Columbia University.

The very title indicates that this is not merely another book on health education. The authors have aimed and succeeded in bringing to school administrators an aid whereby they may be better guided in their understanding of both health and physical education as they should exist in the public schools.

The book is conspicuous in its omission of the old, and many times meaningless, devices around which so many programs are constructed. In its entirety the content of the book is in accord with the new and freer method of education. It is built on the "whys" which, after all, is the surest approach to the child's learning ability. Wherever one opens the book one finds the headings of timely and important questions, and the explanations for them.

The questions as to the teacher's knowledge of signs and symptoms, the facts about vaccination, the duties and remuneration of officials connected with the health program, are fair examples of the method of treatment of the health program in this new book.

Neither in the health nor the physical education part of the book do the authors intend to divulge secrets, but the approach in both instances is of a sort that will serve the administrator

better as a valuable aid in his supervising this service.

While the specially trained physical education teacher should be and is familiar with the important material in his own field, as a health teacher and administrator he needs to familiarize himself with the first half of the book, so as to do his work more intelligently and safely. It is a book, then, that is destined to promote our calling, particularly if it can be brought to the attention of those school officers charged with the responsibility of teaching and supervising this important branch in the program of education.

Carl Schrader,
State Supervisor of Physical Education, Massachusetts.

NATIONAL DANCES OF IRELAND. By Elizabeth Burchenal. G. Schirmer, Inc., New York.

Elizabeth Burchenal, dean of Folk Dancing, and recently proclaimed as one of the ten outstanding women of America, has compiled another folk dance book. Since the appearance of "Folk Dances and Singing Games," at least twenty years ago, this author has produced several notable volumes dealing with this vital phase of the physical education and recreation field. Dances of the People, American Country Dances, Folk Dances of Finland, Folk Dances of Denmark, are among those that come to mind.

This time Ireland has been the field of her research, and she has brought forth a collection of folk dance material that is not only authentic in character, but true to the spirit of a people that through the centuries have risen above all sorrow and anguish to sing and to dance.

The book represents a selection of twenty-five of the most attractive and representative Irish dances, the rhythm and music of which catch the ear and stir the emotions. Equally important is the fact that all the dances, so clearly described, are comparatively simple in character and easy to teach.

Miss Burchenal says in the preface "It is my joy in these dances and my conviction that they will add beauty and color to American life that has given me the temerity to publish them in this form."

Due acknowledgment is made by the author to the courtesy and cooperation of Mr. J. M. Lang, a dancer of note, as well as a leading authority on the national dances of Ireland.

Charles W. Nethaway.
Pittsburgh, Penn.

SCHOOL HEALTH PROGRESS. American Child Health Association, 1930. 343 pp. $1.25.

Since the reorganization, with the approval and support of President Hoover, of various child welfare agencies into the American Child Health Association, marked advance has been made in both the quality and scope of the work in this field. The fifth Health Education conference, held in 1929, has its proceedings in full in this report on School Health Progress.

Experience has demonstrated that while many health problems were common to all school agencies, yet there should be a different approach and emphasis on each age group. The conference was accordingly set up in three sections, representing the three educational levels, namely, Elementary, Secondary and Teacher Training groups. Papers presented by selected speakers were discussed extensively, and while there is little in the report indicating settlement of the problems, there is most encouraging evidence of serious consideration and pooling of experiences on the part of those specializing in this field.

In the elementary school section there was a general agreement on the following objectives — the establishment of habits and attitudes favorable towards the practice of good health; the provision of general knowledge on health subjects to guide the child's actions; and the necessity of surrounding the child with such environment and practices as show examples of the highest health principles. A

tentative program is outlined calculated to attain these aims.

In secondary schools it was agreed that health service should be provided for each pupil throughout the entire span of school life, and that the emphasis might well shift towards health instruction adapted to local needs, as giving an intelligent basis for the health habits advocated; that the principal of each school be the final authority working through a health councillor or committee; and that the curriculum be selected so as attain a definite increase in health knowledge and behavior.

In the teacher training institutions, emphasis was placed upon the cumulative individual records of pupils, prepared with the coordination of various teachers and officers; that opportunities be offered for personal conference with regard to health; and that reports be sent to parents regarding the condition or progress of individual pupils. Suggestions were also made relative to further methods of organization and the basis of selection of health materials in order that teachers might be interested and prepared to promote health education throughout the public school system.

G. B. Affleck,
Y.M.C.A. College, Springfield, Mass.

GROWING STRAIGHT. By Maud Smith Williams. A. S. Barnes & Co., 1930. 137 pp. $2.00.

The author claims that as a result of extended and intimate acquaintance with North American Indians she has learned some of their secrets of health and efficiency, and she undertakes to set forth with explanation some of their practices. There are many good suggestions particularly relative to such topics as mental control, overcoming fear, development of courage, influence of mental attitude, etc. Line drawings illustrate the exercises used by the Indians and make clear certain points of difference between those of aborigines and those accepted by present day civilization. The writer has introduced a good deal of the metaphysical and speculative, resulting in some rather startling claims for this "Indian System." Perhaps emphasis on the mysterious is promoted by the coining of some terms such as "directionalized" instead of direct, and by some explanations which are offered in rather indefinite terms. When it comes to the physiological basis in support or explanation of the practices ascribed to the Indians, there are some fundamentals which seem to differ radically from those generally accepted. Among these may be noted the following:

"It (deep breathing) serves to increase the weight of thin emaciated persons or those wasted with disease, and also aids in the reduction of excessive fat through proper oxygenation. The living cells of the body obtain their electric life essences through the air from the sun," page 15. "Life enters the body with the incoming breath and departs with the outgoing breath," page 16. "The blood uses oxygen from the air while the nerve system uses a certain electric force radiated by the sun and contained in the ethers..." "Man alternates in polarity with every breath." "One nostril is for the positive and the other for the negative life currents," page 16. "Air enters the pores carrying the electric life giving currents into the body where it is immediately taken up by the blood. Radio electric messages also reach the nerves through the pores of the skin," page 17. "There is a mysterious 'inner breath' known to a few highly developed American Indians, and practiced by them when going through fire, under water, through dense smoke, or during profound spiritual medication. With this method they do not employ the lungs but directionalize the life forces through the spinal nerve centers to the brain, using the pneumogastric nerves," page 18.

Instructions and explanations with regard to breathing contain the following: "Inhale...keep the mouth closed. Begin at the diaphragm a little below the waist line and gradually

draw the air up into the lungs...," page 20. "If a feeling of dizziness is experienced when first practicing the full breath, be assured that it is much needed for it is an indication of weakness through disuse of the lungs and the muscles which support them," page 21. "Exhale thoroughly to be sure that the lungs are entirely empty," page 21. "Every movement of muscle or nerve whether voluntary or involuntary is directed by a subtle influence or suggestion of mind," page 22.

The book leaves one with a peculiar feeling that without doubt Indians have learned empirically certain procedures which contribute to health and endurance, though how much they differ from whites living under similar conditions may very properly be questioned. But the physiological explanations submitted are to say the least, not satisfactory.

G. B. Affleck,
Y.M.C.A. College, Springfield, Mass.

PERSONAL AND COMMUNITY HEALTH. By Clair E. Turner. C. V. Mosby Company, St. Louis, Mo., 1930. 443 pp. $2.50.

Since the appearance of the first edition of this text by Prof. Turner in 1925, it has proved so popular that it has already passed through two revised editions. It is especially designed for students in college, normal and professional schools. The majority of texts on hygiene are prepared by physicians, who naturally are inclined to emphasize the pathological rather than the normal, the cure rather than the prevention of disease; to employ more or less technical medical terms and to present the medical viewpoint.

Prof. Turner's treatment in the section on Personal Hygiene (151 pages) stresses the value of maintenance of individual health, outlining the scientific principles on which are based the habits conducive to health. Even the section on Community Health, which topic includes the school and industry, gives prime consideration to health dangers arising from other than communicable diseases. In the infective group the selection includes the three great plagues—common colds, tuberculosis, and syphilis, with each of which personal guidance of life is so significant; while the strictly medical aspects of control of communicable diseases is relegated to two appendices.

In the third (1930) edition, there is a revision of practically the entire text, the omission or replacement of some paragraphs and the addition of others, including a splendid nine page chapter on Health Maintenance. Some additional illustrations are included.

The material is well arranged, presented in a most interesting manner. Typographically the book is all that could be desired, and for students desiring a general sketchy view on hygiene, it is commended even more highly than the previous editions.

G. B. Affleck,
Y.M.C.A. College, Springfield, Mass.

WOMEN AND ATHLETICS. Compiled by the Women's Division, National Amateur Athletic Federation. A. S. Barnes Company, New York, 1930. 75 cents.

Fifteen outstanding leaders have written for the National Amateur Athletic Federation short articles upon timely topics in the field of Athletics for girls and women. This material is presented under the following headings: General, Competition, Organization, Play Days, Olympics. The platform, organization, aims, activities, membership and resolutions of the National Amateur Athletic Federation are also included.

The book presents in a direct and concise manner the accepted educational policies relative to athletics and sports for girls and women. Anyone called upon to build or evaluate such a program will do well to use this publication as a measuring stick.

Emma L. Wilder,
Department of Physical Education for Women, LaCrosse State Teachers College, Wisconsin.

GREEK PHYSICAL EDUCATION. By Clarence A. Forbes. The Century Company, 1929. 300 pp. $2.25.

When in 1910 E. Norman Gardner's "Greek Athletic Sports and Festivals" was published in the United States, it was regarded by many as the last word on this topic. That splendid text is now out of print, and can be secured only at a considerable premium in price.

Now Dr. Forbes of the classical department of the University of Nebraska has approached Greek physical education from a somewhat different point of view. After considering the somewhat speculative origins of this education in Greece, the author perforce proceeds to consider the details of various city-states.

Of these the most vigorous in its requirements was Sparta, which subjected the individual to the interests of the state, and so took charge of the boys, and to some extent also of the girls, at the age of seven, organizing them into bands and submitting them to the strictest discipline and most severe physical exercises, actually flogging those who showed lack of development. The result of this "survival of the fittest" policy was a Spartan showing splendid physique, exceptional health and endurance, while his courage and obedience were exemplary.

Crete had a much milder form in which the youth joined bands under leaders, but were not graduated into the state training fields until about the age of twenty, at which time they assumed the oath of citizenship. The duration and severity was much less than in the case of Sparta.

The Athenians represented the sanest and best balanced attitude, combining health, strength, agility with beauty, "music" to learning and moral training. But even here the relation of education to military preparedness was prominent. Following the Persian wars there was a surge of interest in health and physique, even as the World War experiences showed the value of physical health as a national asset. Medical gymnastics was given some attention but naturally was empirical rather than scientific. In later Greek days much of the idealism which prevailed in the Golden Age was lost as the idea of beauty and grace gave place to that of strength and skill. Prominent among the causes of the decline of physical education in Greece was professionalism which placed its emphasis upon victory in contests rather than in all-round and beautiful development.

Some idea of the prominence given by Greece to physical education may be secured from the extent to which it is given a place in the philosophy of such Greek writers as Xenophon, Aristotle and Plato. Very good summaries of their ideas are given by the author, although in the majority of the cases the plans advocated were theoretical rather than practical. Further evidence of the place of physical education in the Greek life may be gathered from the fact that "Every self-respecting community erected a gymnasium at public expense" (page 260).

The text is most scholarly, drawing as it does not only from Greek but also largely from French and German sources; in fact the critical considerations of uncertain points, disputed dates, and technical terms is given so much space that the discussion becomes almost too academic to be of interest to the general reader or even to the physical director.

In the exceptionally complete bibliography one notes the absence of Bishop Potter's "Archaelogia Graeca," a splendid four book publication, which bears internal evidence of having been a source of material for the studies by Boykin and Hartwell, which were published in the report of the United States Commissioner of Education in the nineties.

Physical education as well as history in general is placed under deep obligation to Professor Forbes for this exceptionally painstaking and exhaustive study. It is a source of delight as well as information to those who are really interested in the subject, and

should help in securing a more adequate idea of both objectives and relationships in physical education.

There is yet to be written a satisfactory treatise on physical education in relation to art. Greece is a rich source for material of this kind, and while there has been more or less appreciation of the artistic throughout various countries, it is only recently that a real beginning in the recognition of this intimate relationship has been made in this country. If the artistic can be introduced to replace some of the undue interest in professionalism, it may be the means of saving some of the finer values in physical education.

G. B. Affleck,
Y.M.C.A. College, Springfield, Mass.

THE FOOTBALL QUIZZER FOR 1930. By William J. Sheeley. A. S. Barnes & Company, New York City. 99 pp. $.50.

Mr. Sheeley, by means of the Football Quizzer for 1930, has given to players, coaches, officials and spectators an invaluable aid in becoming better acquainted with the game of football, its rules and regulations. With but one or two minor exceptions the author has followed, in methodical order, the official football rules, thus making it easy for those interested to make comparisons with the Official Guide. The writer has presented each rule by the question and answer method, using as many queries and replies as necessary to clarify each complete rule, its sections and articles. A typical illustration of his procedure is offered in the first rule of the Official Guide. He divides the paragraph in Rule I, Section 1, into three separate and distinct questions and answers, presenting the dimensions of the regulation field, describing the field of play, and outlining the end zones. The author has also supplemented his interpretations by case studies, typical plays and situations. The book is one that will adequately fill the needs of instructors conducting courses in officiating, coaches who are desirous of having their players know the rules, officials holding discussion meetings, and spectators who want to become better acquainted with the rules of the game. Coaches and officials can materially aid Mr. Sheeley in making future editions of the "Quizzer" even more enlightening by submitting unusual plays and situations that occur during the current season.

A. A. James,
Intramural Dept.,
University of Michigan

INDUSTRIAL ARTS FOR PUBLIC SCHOOL ADMINISTRATORS. By Frederick C. Bonser. Bureau of Publications, Teachers College, Columbia University. 96 pp.

Industrial Arts for Public School Administrators is in essence a composite philosophy of the industrial arts. Dr. Bonser has admirably brought together in short, concise form a very readable summary of what many of our best educators are thinking about industrial arts and the place it should hold in our present school systems.

Dr. Bonser begins by giving us very briefly a general view of the field. The definition of industrial arts, the changes in terms and purposes, the place of industrial arts in the curriculum, and the types of industrial arts best suited for the several school levels are all briefly discussed.

Section II discusses the place of industrial arts in the elementary school. In this section the author takes up the purposes of industrial arts in the elementary school, the course of study, its relation to other subjects, materials, equipment, time allotment, and proper methods of supervision.

Sections III and IV have to do with industrial arts in the junior and senior high school. In section III the author stresses the necessity for variation of work to suit multiplicity of interests found in the junior high school. Objectives, how they are determined, and methods of attaining them are discussed in a very helpful way. In section IV the place of industrial arts in

the senior high school is treated very much the same way as was industrial arts in the junior high school. Dr. Bonser brings out quite clearly that the work at the junior high school level must not in any way be of a vocational nature but that, for certain schools, the work in the senior high school may take on more of a vocational aspect.

This book will be of great assistance to superintendents and principals of smaller systems where a special supervisor is not available. It is to be hoped that it will fill a long-felt want in clearing up the be-fogged thinking among superintendents and principals of smaller towns and cities as to the aims and objectives of the industrial arts and their places in our schools.

M. L. Byrn,
Head of Industrial Arts Department, University High School, Ann Arbor, Michigan.

LABORATORY MANUAL IN COLLEGE PHYSIOLOGY. By Cleveland Pendleton Hickman, Ph. D. The Macmillan Company, New York. 1930. 106 pp. $?.

The text aims to unite the standard physiological experiments with some of the newer physical and chemical methods. The book is planned to take six hours a week of laboratory work for one semester. Each chapter of experiments is introduced with a helpful, concise summary. The text gives a complete list of supplies necessary for the course.

There are thirteen chapters:

I. General Plan and Structure of the Body.
II. General Phenomena of Protoplasm.
III. Circulation.
IV. Blood and Lymph.
V. Respiration.
VI. Excretion.
VII. Animal Heat and Regulation.
VIII. Chemical Regulation of the Body.
IX. Foods and Nutrition.
X. Digestion.
XI. Muscle and Nerve.
XII. The Sense Organs.
XIII. Reproduction.

The text gives a very good selection of experiments for a general college course in physiology. Courses in physiology for students of physical education would want to have added additional experiments in heart rate, circulation, respiration, particularly in relation to different types of exercise.

J. H. McCurdy, M. D.
Y. M. C. A. College,
Springfield, Mass.

FIELD HOCKEY FOR COACHES AND PLAYERS. By Hilda V. Burr. A. S. Barnes & Co. 194 pp. $2.00.

This book, as suggested by the title, is adapted to players and coaches. It is so simply written that the novice with little knowledge of the game would have no difficulty interpreting the meaning, while, at the same time, the subject is so fully covered and the material so organized, that the advanced player or the hockey coach will find it of great value in the technical points of the game and in the coaching hints given.

Each position is adequately analyzed and useful suggestions for improvement of play presented. Players would do well to study this book and endeavor to incorporate many of the ideas into their game.

A chapter on Stickwork Practice and Relay Games is included. There is a fund of material in this chapter which can well be used for all grades of players. The formations are varied enough to make the presentation of technique interesting and various combinations are well worked out. Diagrams serve to make clear the numerous formations suggested.

The author, because of her experience, is able to give us a more complete analysis of the game than has so far been attempted. This book would serve as a valuable text for students of the game. It fills a much-felt need and should go a long way in raising the level of American hockey.

Laurie E. Campbell,
University of Michigan.

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of the American Physical Education Association

Address Box 362, Ann Arbor, Mich.

The recently published study "Physical Education Curriculum in Professional Schools" by the Committee on the Curriculum of the 139 institutions preparing teachers of Physical Education in the United States is available at the regular prices, i. e., $5.00 single copies, and $3.00 each additional copy.

The "Review," back copies to 1898: Single copies, 50c; three copies, $1.00; One volume, ten copies (unbound), $3.00; One volume, (bound), $5.00. (Postage prepaid).

The "Pentathlon" for Oct., Nov., and Dec., 1929, 25c each.

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Requirements for Graduation

Completion of 31 semester hours of work on the graduate level in addition to fulfillment of undergraduate professional requirements. Courses offered include:

Physical Education Seminar: Covering advanced and original work.

Character Education: Discussions and examination of the literature on the subject.

Experimental Physiology: General Survey with selection of individual topic by student.

Experimental Physics: Study particularly of Physics in relation to animal mechanics.

Thesis: An experimental study of some essential topic.

40 students in Graduate Division of Summer School for 1929.

20 Graduate students during current year, 1929-1930.

400 men in the undergraduate department during the current year.

J. H. McCURDY, A.M., M.D., M.P.E., *Director*
GEORGE B. AFFLECK, A.M., M.D., M.P.E., *Associate Director*
JOHN D. BROCK, *Secretary*

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